ANATOMY
OF THE
BRAIN AND SPINAL CORD

BY

J. Ryland Whitaker.

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OF THE

BRAIN AND SPINAL CORD

BY

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TO

WILLIAM SCOVELL SAVORY

PRESIDENT OF THE ROYAL COLLEGE OF SURGEONS, LONDON,

FELLOW OF THE ROYAL SOCIETY, ETC., ETC.

This Little Manual is Respectfully Dedicated

IN MEMORY OF MANY KINDNESSES.

THE AUTHOR.

PREFACE.

My only apology for publishing this little book on the "Anatomy of the Brain and Spinal Cord," when so many excellent manuals already exist, is that I have been repeatedly requested to do so. The work pretends to no originality, liberal use having been made of the various well-known text-books, such as Quain, Turner, Ecker, Henle, Holden, Gowers, Ferrier, Wilks, and many others. It merely embodies the series of Demonstrations on the Brain and Spinal Cord which it has been my pleasant duty, for several years past, to give to the senior students of the Edinburgh School of Medicine, Minto House. This will, in a great measure, account for the somewhat conversational style adopted. The order followed will be self-evident on inspection of the Table of Contents. In lettering the plates, if the entire name has not been printed, the initial letters of the name have been used, so that when referring (in the text) to the various figures the letters have not been again employed—the initials of the names indicating the lettering on the plates. Many of the figures have been taken, by the kind permission of Dr Symington, from the beautiful preparations in the Anatomical Rooms, at Minto House; others are from the sources indicated below, (List of Plates, page vii.). To Dr Symington also I am indebted for many valuable suggestions and much help; and to my friend and fellow demonstrator, Mr Kent, and to the several students, who at great inconvenience to themselves, have more than once read over the manuscripts and proofs, I cannot sufficiently express my gratitude. Any merit or success which the book may have is in a great measure due to them. Finally it only remains for me to thank Mr J. T. Murray for the time and trouble he has taken in the reproduction of the plates, and the publishers, Messrs Livingstone, for their uniform courtesy and excellent execution of the work.

32 Castle Terrace, Edinburgh,
March 1887.

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ERRATA.

Page 18. . . *For* (fig. 12,) i.l., *read* l.v.
" 22. . . *For* Haddon *read* Hadden.
" 32. . . *For* contains *read* contain.
" 34. . . *After* petrosals *insert* the two laterals.
" " line 20. *For* before, backwards, *read* behind, forwards.
" 39. . . *For* Wellis *read* Willis.
" 56. . . *For* (fig. 38,) d.a.t., *read* a.f.
" 58. . . *For* (fig. 38,) a.s., *read* a 5th.
" 62. . . *For* valleculæ *read* vallecula.
" 64, line 3. *For* superior *read* inferior.
" " Plate 12, fig. 45. *Invert* inner and outer.
" 77, line 20. *For* horizontal *read* longitudinal.
" 90 & following. *For* Munro *read* Monro.
" 91 & following. *For* centre *read* centrum.
" 93. . . *For* dissection, p. 68, *read* 91.
" 94, line 29. *After* backwards *insert* then inwards.
" 101, line 1. *After* body *insert* of the.
" 104. . . *For* Function *read* Functions.
" 105. . . *For* runs *read* run.
" 107. . . *For* tænia *read* tæniæ.
" 110, line 17. *For* anterior *read* posterior.
" 118, line 12. *For* origins *read* origin.

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THE

CEREBROSPINAL NERVOUS SYSTEM.

THE **Cerebrospinal Nervous System** is made up of the Brain and Spinal Cord. Surrounded by the bony wall of the Cranium in the one case, and of the spinal canal in the other, these two parts of the great central nervous system are continuous with each other through the foramen magnum. They are enveloped in three distinct membranes, the meninges, which form additional protective sheaths around them, and help to support them in their respective cavities.

The Brain and Spinal Cord are each composed of two kinds of nervous substance, known from their colour as the Grey and White Matter respectively; but with this difference in their arrangement, namely, that in the Brain the grey matter is situated chiefly on the outside, forming the so-called cortex; whilst in the Spinal Cord the white substance is external, and the grey matter forms the central core or pith.

CHAPTER I.

THE SPINAL CORD

AND ITS

MEMBRANES.

DISSECTION.—To see the spinal cord and its membranes it will be necessary to open the vertebral canal. To do this, remove all the muscles from the vertebral grooves, and then saw through the laminæ on each side close to the spinous processes, being careful, especially in the dorsal region, to direct the edge of the saw inwards. Carry the incision downwards as far as the lower end of the sacral canal, and upwards as high in the neck as is convenient. Break through any partially sawn arches with the chisel, cut through the ligaments, and remove the pieces of bones thus detached. After having cleared away the connective tissue, veins, and fat covering its outer aspect, the tube of dura mater will be exposed. One or more of the processes passing through the intervertebral foramina should be followed by snipping through the articular processes with the bone forceps. After examining its outer surface, slit open the dural sheath by a longitudinal incision in its entire length.

Section I.

MEMBRANES OF THE SPINAL CORD.

(See Plates 1, 2.)

These are identical in many respects with those of the Brain, and are therefore similarly named. They are the Dura Mater, the Pia Mater, and the Arachnoid. The Dura Mater is the most external, the Pia Mater is in close contact with the cord, and the Arachnoid forms a vertical, tubular partition between the others, dividing the space between them into two, viz., the Subdural and Subarachnoid. Thus we speak of the Subdural space, meaning that between the Dura Mater and the Arachnoid, and of the Subarachnoid, or that between the Arachnoid and the Pia Mater.

I.—THE DURA MATER.

(Figs. 1, 2, 3, 4, d.)

The **Dura Mater,** the most external and the strongest covering of the cord, is a firm fibro-serous membrane, continuous at the foramen magnum with the similar membrane which lines the cranial cavity. Enclosed in the spinal canal, it does not, however, form an endosteum to the bones, and differs in this respect from the cranial dura mater. Its outer surface has a shining, pearly white appearance, and is separated from the walls of the canal by a little fat and loose areolar tissue, and a plexus of veins. Slender fibrous bands, especially at its lower end, attach it closely to the posterior common ligament of the vertebræ. In extent the dural sheath reaches from the foramen magnum to the second or third piece of the sacrum, and, as you will see on opening it, its cavity is much longer and wider than its contents, for the cord ends at the first or second lumbar vertebra. Below the termination of the spinal marrow (conus medullaris) the cavity of the dural sheath is occupied by bundles of nerve roots—*canda equina* (fig. 5, c.e.)—in the midst of which you will be able to pick out a slender, silvery-looking thread, the *filum terminale* or central ligament (fig. 5, f.t.). Attached to the apex of the conus medullaris this terminal filament runs down amongst the nerve roots to the lower end of the dural cavity, and there, piercing the dural sheath, receives an investment from it, and passes, to be attached along with this investment, to the back of the sacrum or coccyx (fig. 5, f.t.). Thus, then, we see that the dura mater forms a very loose covering to the cord, and we find, moreover, that it has a greater capacity in the neck and back than it has in the loins. Smooth and glistening on its inner aspect, it presents a series of rounded openings, arranged in pairs, one for each spinal nerve root. These roots, as they pass out to the intervertebral foramina, carry with them a prolongation of the dura mater (figs. 2, 3, 4, d.).

It is important to recollect that, although the cord itself ends at the spot indicated, the dura mater, the arachnoid, and the cerebrospinal fluid extend as far as the second piece of sacrum, so that injuries inflicted upon the spine as low down as this latter point may cause death by inducing inflammation of the meninges.

MINUTE STRUCTURE OF THE DURA MATER.—Under the microscope the dura mater will be seen to consist of white fibrous and elastic tissues, arranged in longitudinal bands or lamellæ, with flattened, branched, connective tissue corpuscles, clasping the bundles of fibrils. Both its inner and outer surfaces are smooth and covered by endothelial plates. Many lymphatics and blood-vessels, as well as slender nerve filaments, derived from both spinal and sympathetic systems, are furnished to its substance.

PLATE 1.

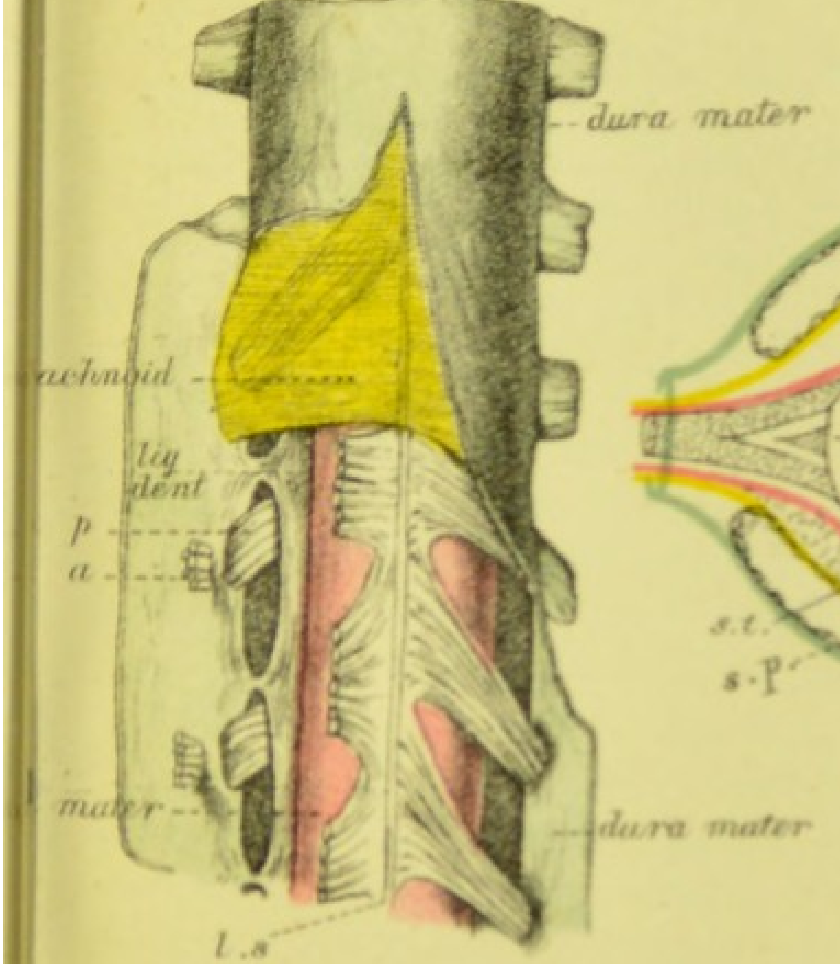

Fig. 1.

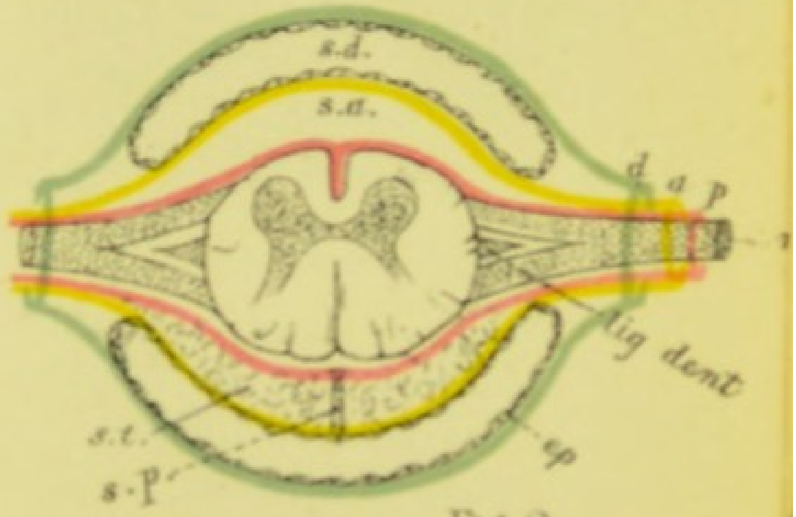

Fig. 2.

Fig. 3.

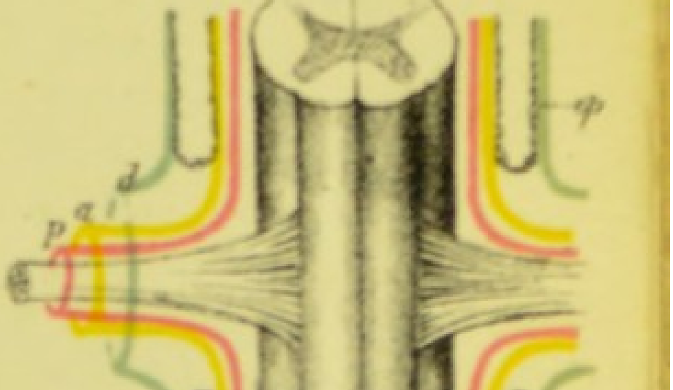

Fig. 4.

II.—THE PIA MATER.

(Figs. 1, 2, 3, 4, p.)

DISSECTION.—After slitting open the dura mater, the first membrane you will see is the delicate arachnoid. Pierce it with a sharp-pointed blow pipe and inflate, as far as you can, the subarachnoid space. Next, to expose the pia mater, remove a small piece of the arachnoid from any part of the cord, leaving it intact elsewhere.

For convenience we shall describe first the Pia Mater, then the Arachnoid.

The **Pia Mater** is a delicate, highly vascular, fibrous membrane, which so closely surrounds the cord that it cannot easily be stripped off. A process or fold (fig. 3, f.) passes from it into the anterior median fissure of the cord, and it also furnishes sheaths to the roots of the spinal nerves (figs. 2, 3, 4, p.). If you compare it with the pia mater of the brain, you will find that it is thicker, less vascular, and more adherent to the subjacent nervous tissue. Some anatomists describe two layers in the pia mater of the cord, an inner and an outer layer, differing in the arrangement of their constituent elements. Of these the former only is represented in the pia mater of the brain.

The outer surface of the pia mater is comparatively rough, and presents along its anterior aspect a thickened fibrous band, the so-called "linea splendens" (fig. 1, l.s.). This is sometimes difficult to make out. Another well-defined structure, the *ligamentum denticulatum* (fig. 1 and 6, lig. dent.), also runs longitudinally on each side of the cord in the form of a toothed, white band, having its serrated edge turned outwards. This ligament helps to support the spinal marrow within its dural sheath. Internally it is attached to the pia mater, about midway between the lines of origin of the anterior and posterior nerve roots, reaching upwards as high as the medulla oblongata, and ending below on the pointed extremity of the cord (conus medullaris). Externally, its outer margin forms a series of tooth-like processes (fig. 1 and 6, lig. dent.), about twenty-one in number, which are fixed to the inner surface of the dura mater; the highest of these denticulations is attached opposite the margin of the foramen magnum, and the lowest opposite the twelfth dorsal or first lumbar vertebra. The ligamentum denticulatum thus partially divides the subarachnoid space into an anterior and a posterior compartment (fig. 3, lig. dent.). Further, at the back of the cord is another process or partition—the "septum posticum" (figs. 2. 3, s.p.)—which also crosses the subarachnoid space and serves to connect the pia mater with the arachnoid.

Below the end of the cord the pia mater, though still retaining its tubular form, becomes suddenly reduced in size, and is prolonged as a mere fibrous thread,—the *filum terminale* or central ligament (fig. 5, f.t.). In its upper half this filum terminale encloses the continuation of the central canal of the spinal cord, surrounded above by a little grey matter; but, opposite the first or second sacral vertebra (fig. 5, f.t.), it pierces the dura mater, and, receiving an investment from it, ends below by blending with the periosteum of the sacrum or coccyx (fig. 5, f.t.). Its silvery hue enables us to distinguish it among the surrounding bundle of nerve roots (cauda equina).

Lying between the pia mater and the arachnoid, and connected with both, is a quantity of delicate connective tissue in the form of a spongy network, the subarachnoid trabeculæ (figs. 2. 3, s.t.), the interstices of which are lined by endothelial plates. It is in the lacunæ or areolæ, thus formed, that the greater part of the cerebrospinal fluid is contained.

Minute Structure of the Pia Mater.—The basis of the pia mater is simply white fibrous connective tissue, arranged in interlacing bundles. As before mentioned, two layers have been described in the pia mater of the cord, but the difference in their structure is very slight. Both its surfaces are covered by endothelial cells. It possesses a complete network of lymphatics and blood-vessels; and its nervous supply is derived from the sympathetic system.

III.—THE ARACHNOID.

The **Arachnoid*** is an extremely fine and delicate membrane. It is non-vascular, and thus differs materially from the other two. Its arrangement is by no means easy to understand, the difficulty being increased by the fact that different descriptions of it are given in the various text-books.

Forming a cylindrical partition between the dura mater and the pia mater, the arachnoid divides the

* The description of the Arachnoid membrane given in the text is the one usually taught, but no one seems to understand the precise arrangement. Dr Batty Tuke, in a paper published in the *Edinburgh Medical Journal*, (June 1882), maintains, with much show of reason, that a separate arachnoid membrane does not exist, and that what is usually regarded as such is merely one of the layers of the pia mater.

space between them into two — the Subdural and Subarachnoid, previously referred to. The Subdural space is very narrow, for the outer surface of the Arachnoid is in more or less close contact with the dura mater. The Subarachnoid space is much larger; is crossed by the subarachnoid trabeculæ; and contains the chief part of the cerebrospinal fluid. Moreover, the Arachnoid forms tubular prolongations around the processes of the ligamentum denticulatum (fig. 3, lig. dent.), and similar coverings are furnished to the roots of the spinal nerves. These sheaths enclose the nerves as they pass outwards to the dura mater, but, when the nerve roots pierce that membrane, the epithelium of the outer surface of the arachnoid becomes continuous with the epithelium lining the inner surface of the dura mater (fig. 2 and 4, ep.), whilst the rest of the arachnoidal sheath blends with the perineurium of the nerves (fig. 2 and 4, a.). Thus we see that each spinal nerve receives a covering from all three membranes of the cord (figs. 2, 3, 4, n.). It is stated, too, that the Subdural and Subarachnoid spaces, though they do not directly communicate with one another, are still both continuous with the lymphatic plexus which surrounds the spinal nerves. It may perhaps be well to mention that the Subdural space was formerly spoken of as "the cavity of the arachnoid"—the arachnoid membrane itself being then looked upon as a serous membrane, enclosing a serous cavity, and the epithelial lining of the dura mater as one of its layers.

Minute Structure of the Arachnoid. — The

Arachnoid consists of bundles of white fibrous tissue, interlacing with one another and arranged for the most part longitudinally. Both its surfaces are covered by endothelial cells. The sources from which it derives its nerves are still very doubtful; most probably they are of sympathetic origin.

THE CEREBROSPINAL FLUID.

The CEREBROSPINAL FLUID, about 2 fl. oz. in quantity, is a clear-looking, alkaline, albuminous liquid, which occupies the interstices of the subarachnoid trabeculæ. By its means, probably, an equality of pressure is maintained upon the brain and cord, hence we find that any sudden disturbance of the fluid, such as would be caused by pressure on a spina bifida, at once gives rise to serious cerebral symptoms—*e.g.*, loss of consciousness.

Section II.

THE SPINAL CORD.

The **Spinal Cord** is the elongated cylindrical mass of nervous substance contained in the vertebral canal. Invested by three meninges, it gives origin to thirty-one pairs of spinal nerves; is partially divided by anterior and posterior median fissures into two lateral segments; and is composed of two kinds of nervous substance—an outer cortical part, consisting principally of white or medullated nerve fibres, and an inner grey core or pith, consisting chiefly of nerve cells and nerve cell processes. You have already seen that the spinal marrow is much smaller than the capacity of its bony case, so much so, that, in the adult, it occupies only about two-thirds of the length of the spinal canal. About eighteen inches long, the spinal cord reaches from the foramen magnum to the lower border of the first or second lumbar vertebra. Above, it is continuous with the medulla oblongata; below, it ends in a pointed extremity, the conus medullaris, from the apex of which the filum terminale is prolonged downwards. According to the regions of the spine in which they are situated, different portions of the cord have received special names; thus we speak of the cervical, dorsal, and lumbar portions. The spinal cord moreover presents two swellings or enlargements—an upper one, the cervical enlargement, extending from the third cervical to the first dorsal vertebra, and a lower or lumbar enlargement, which, beginning at the tenth dorsal vertebra, is largest opposite the twelfth, and then gradually tapers away to the pointed extremity of the cord. The connection between the increase of nervous substance in these two parts of the cord and the origin of the large nerves given off to the upper and lower limbs respectively is sufficiently obvious.

1. **Fissures of the Cord.**—On both anterior and posterior aspects of the spinal cord there is seen a median longitudinal cleft or depression, which penetrates some distance into the nervous substance, and partially divides it into two lateral halves. These clefts are called the Anterior and the Posterior Median Fissures. The ANTERIOR MEDIAN FISSURE is the wider of the two, though in depth it extends through only

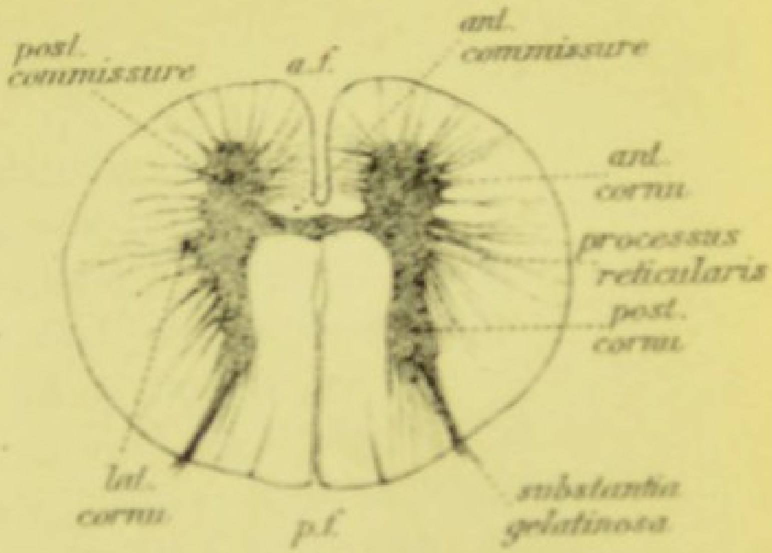

Fig. 8.

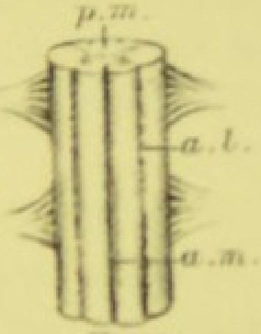

Fig. 7.

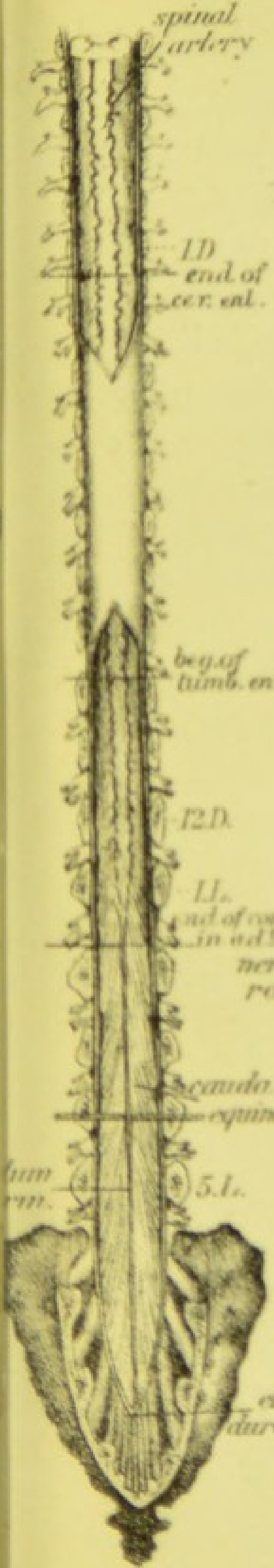

Fig. 5.

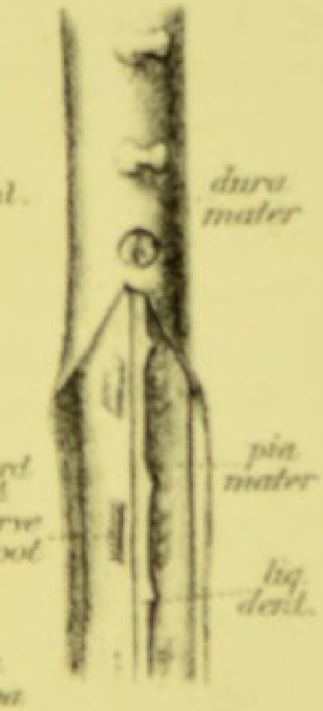

Fig. 6.

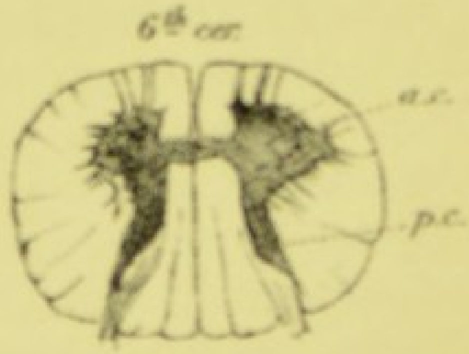

Fig. 9.

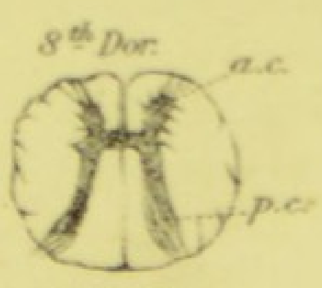

Fig. 10.

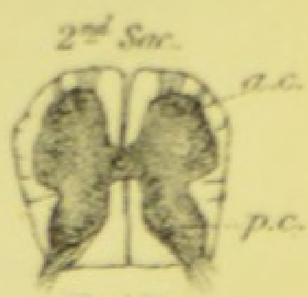

Fig. 11.

one-third of the thickness of the cord. It contains a distinct fold of the pia mater, which conveys blood-vessels into the interior of the spinal marrow (fig. 3, f., and fig. 19). At the bottom of this fissure lies a transverse band of nerve fibres, the *anterior* or *white part of the commissure* (fig. 8, a.c.), which connects the two lateral halves of the cord. The POSTERIOR MEDIAN FISSURE is rather a septum than an actual fissure, for it does not contain a fold of the pia mater, but is filled up by connective tissue (neuroglia) and blood-vessels. The *posterior* or *grey part of the commissure* lies at the bottom of this septum (fig. 8, p.c.).

In addition to these median fissures, we have yet to describe, on each side, two lateral longitudinal depressions, the positions of which are indicated by the lines of origin of the anterior and posterior nerve roots. They are called the ANTERO-LATERAL and POSTERO-LATERAL grooves, and they mark off the surface of each half of the cord into three columns,—an anterior, a lateral, and a posterior. The *anterior column* lies between the anterior median fissure and the anterior nerve roots; the *lateral column* between the nerve roots; and the *posterior column* between the posterior nerve roots and the posterior median fissure* (fig. 7).

In the cervical region, close to the posterior median

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* Some authors divide the cord thus:—1. Posterior segment—between the posterior median fissure and the posterior nerve roots. 2. Antero-lateral segment—between the anterior median fissure and the posterior nerve roots. This antero-lateral column is again divided, by the groove along which the anterior nerve roots take origin, into *(a)* an Anterior part, between the anterior median fissure and the anterior nerve roots; *(b)* a Lateral part, between the anterior and posterior nerve roots.

fissure, an additional slightly marked cleft can be made out, which, together with other minor septa, breaks up the cord into many tracts or columns which will be described hereafter.

2. **Spinal Nerves.**—Along the sides of the spinal cord arise the thirty-one pairs of spinal nerves, each taking origin by two roots—ANTERIOR and POSTERIOR, springing from the antero-lateral and postero-lateral grooves respectively. They are enclosed in sheaths similar to those of the cord itself, and pierce the dura mater by two separate openings, one for each root (fig. 1, a. and p.). These nerves, with the exception of the first or highest, are not attached to the cord opposite the vertebra below which they leave the vertebral canal, but at a higher level. This difference between the points of origin and exit (a matter of considerable clinical importance), though slight in the cervical region, increases as we descend the cord, until at its lower end the nerve roots form an almost vertical bundle, known as the *cauda equina.*

3. **Spinal Vessels.**—The arteries on the surface of the spinal cord are the Anterior and Posterior Spinal. The ANTERIOR SPINAL ARTERY, formed above by the union of two branches, arising one from each vertebral artery, runs along the front of the cord underneath the linea splendens, and is reinforced, as it passes downwards, by a series of anastomotic branches from arteries in the neck and back. It gives off branches to the roots of the spinal nerves, to the anterior median fissure, to the pia mater, and ends below upon the filum terminale. The POSTERIOR

SPINAL ARTERIES are two in number, running downwards, one on each side, behind the line of origin of the posterior nerve roots. They are derived from the same source as the Anterior, and are joined by small branches which enter the intervertebral foramina along the roots of the spinal nerves. They anastomose freely and send offsets into the Posterior median fissure.

4. **Grey and White Matter of the Spinal Cord.**—A transverse section of the spinal cord, such as that represented in figs. 8, 9, will show you distinctly its subdivision into two lateral halves, and will demonstrate clearly the existence of the central grey core, of the white cortex, and of the twofold commissural band of white matter (anterior) and grey matter (posterior), connecting together its lateral segments.

(I.) The **Grey Matter** occupies the centre of the cord, and is completely surrounded by the white substance. It forms a double column, extending through the entire length of the cord and is united across the middle line by a vertical grey band—the posterior commissure. In transverse section, therefore, it presents more or less the appearance of the capital letter H, for it is arranged in two irregularly crescentic masses,—one in each lateral half of the section. These two grey crescents are united across the middle line by a transverse band of grey matter—the cross-bar of the H—which represents the grey or posterior part of the commissure previously mentioned. Each grey crescent is semilunar in shape, having its horns or cornua pointing, the one forwards and outwards, the other backwards and outwards; hence they are known as the ANTERIOR and the POSTERIOR CORNUA. The convexity of each grey mass looks inwards towards the middle line, whereas the corresponding concavity is directed outwards.

1. Cornua.—The ANTERIOR HORN of each crescent, irregular in outline, is, for the most part, shorter and thicker than the posterior, and arches outwards towards the place of origin of the anterior nerve roots. It does not, however, quite reach the surface of the cord, some white matter being interposed.

The POSTERIOR HORN, on the other hand, is longer, more slender and pointed than the anterior, and almost reaches the surface of the cord at the fissure along which the posterior nerve roots take their superficial origin. Here it tapers to a point, called the *apex* cornu posterioris, which contains a stratum of rather clear-looking connective tissue, known from its gelatinous aspect as the *substantia gelatinosa* of Rolando. Near its base the posterior horn is somewhat constricted, forming the so-called *cervix* or neck, while to the slightly enlarged part between the apex and neck the term *caput* cornu posterioris has been applied.

Now, examine the outer concave side of each crescent slightly behind its centre and you will find that the grey matter here assumes the form of a network, projecting out into the white substance. This network has received the name "processus reticularis" and is best seen in the cervical region. Immediately in front of this process, and about midway between the anterior and posterior cornua, lies a pointed collection of grey matter—the INTERMEDIO-LATERAL TRACT, which may be regarded as a lateral horn. Look for it especially in the dorsal region.

If, now, you take a series of transverse sections from the different regions of the cord and compare them, you will find that the grey matter is relatively most abundant in the lumbar region, and least so in the cervical. Again, if you notice the relative sizes of the anterior and posterior cornua of each grey crescent, you will see that in the cervical region the anterior horn is broad, the posterior narrow; whilst both are narrow in the dorsal, and both broad in the lumbar.

2. **Grey Commissure.**—We have already seen that the convex sides of the two crescents are united across the middle line by a band of grey nerve substance, forming the POSTERIOR or GREY part of the COMMISSURE, which connects together the lateral segments of the cord. This band is placed nearer their anterior than their posterior ends, and consists of cells with transverse nerve fibres. About its centre is seen a small opening—the central canal or ventricle of the spinal cord. This canal is the remains of the primitive medullary canal of the embryo, and extends throughout the entire length of the spinal marrow. Above, it expands into the fourth ventricle of the brain, whilst below it enlarges, becomes T-shaped in section, and is said by some to open on the posterior surface of the conus medullaris. It is lined by a layer of columnar cells, which are ciliated in the child, though it is doubtful whether they are so in the adult.

MINUTE STRUCTURE OF THE GREY MATTER.—To examine the minute structure of the grey matter you will require specially prepared microscopic sections. Such specimens will show you that there are two chief constituents of the grey matter, namely, (i.) A ground substance or stroma, called NEUROGLIA (nerve glue), and (ii.) NERVOUS ELEMENTS—nerve fibres and nerve cells—embedded in this stroma.

(i.) **Neuroglia** is a delicate and peculiar kind of connective tissue, which pervades both the grey and white substance of the cord, and is of especial interest clinically as being the probable seat of most of the inflammatory processes which affect the central nervous system. It is a fibro-granular material, containing nuclei, and is made up of the following distinct elements:—(*a*) a homogeneous jelly-like matrix, which in sections, hardened in spirit, becomes somewhat granular; (*b*) a network of fine fibrillae, called by Klein "neuroglia fibrils," and said by him to be "in some respects similar to, but not identical with elastic fibres;" (*c*) small branched nucleated cells, known as neuroglia cells; (*d*) certain larger cells, stellate in section and occupying intervals between the nerve fibres—cells of Deiters.

The neuroglia is pretty evenly distributed throughout the grey substance, but around the central canal is a considerable collection of it, which has been called the central grey nucleus. The substantia gelatinosa of Rolando, previously referred to, is a similar accumulation of neuroglia.

The anterior column of the spinal cord, you will remember, had a median division, *direct pyramidal tract*, and a lateral division, *anterior root zone*, (basis bundle). Now, the pyramids of the medulla are, to a small extent only, made up of fibres derived from this inner division (direct pyramidal tract) of its own side; by far their greater part is composed of fibres (crossed pyramidal tract) which come from the *opposite lateral* column of the spinal cord. This crossed tract, after leaving the opposite lateral column, passes upwards and inwards across the anterior median fissure, where it decussates with a similar set of fibres from the other side—constituting together the decussation of the pyramids. Turning upwards it then forms the inner and by far the larger part of the opposite anterior pyramid (fig. 33); the outer and smaller part of the same pyramid being formed by the continuation upwards of the direct pyramidal tract of the same side. Thus, for example, the *left* anterior pyramid is chiefly made up of the *crossed pyramidal tract* of the *right lateral column*, and to a much smaller extent by the *direct pyramidal* tract of its *own* side.

This decussation of the pyramids explains the phenomena of crossed paralysis, by which is meant, that when one side of the brain, say the left, is injured, loss of motion ensues not on that side but on the opposite side of the body.

The outer division of the anterior column of the spinal cord, *antero-external tract*, will afterwards be traced to the following destinations:—I. to the formatio reticularis; II. to the posterior longitudinal bundle; III. to the tract of the fillet (fig. 63).

External Arciform Fibres (fig. 33, p. 48).—These are a set of fibres which arise in the median raphé of the medulla, emerge from the anterior median fissure, cross over the surface of the anterior pyramids, over the lower part of and below the olives, and finally turn upwards, along with the lateral cerebellar tract, to form with it the Restiform Body. They will be again referred to, in treating of the grey matter of the medulla.

SUMMARY.—Thus we see that the medulla oblongata presents four fissures, an anterior, two lateral, and a posterior; three areas, an anterior, with its pyramids and their decussation, a lateral with its olive, and tract of the olivary fillet, a posterior with its funiculus gracilis, funiculus cuneatus, and funiculus of Rolando, and their respective enlargements; finally we have the Restiform body or inferior cerebellar peduncle.

TABLE.—Objects seen on the surface of the Medulla.

(a) 4 Fissures.	Anterior Median. Posterior median. Two lateral.		
(b) 3 Areas.	1. Anterior area.		Pyramids. Decussation of Pyramids.
	2. Lateral area.		Olive. Tract of olivary fillet.
	3. Posterior area.	Lower part.	Restiform body. Funiculus of Rolando and its tubercle. Funiculus cuneatus and its tubercle. Funiculus gracilis and its clava.
		Upper part.	Floor of 4th ventricle.
(c) External arciform fibres.			

TABLE TO SHOW RELATIONS BETWEEN THE WHITE TRACTS OF THE CORD AND THEIR REPRESENTATIVES WHEN SUCH EXIST IN THE MEDULLA.

	Cord.	Medulla.
Anterior column.	1. Direct pyramidal tract passes.	to outer part of the anterior pyramid of the medulla of the same side.
	2. Mixed zone.	to posterior longitudinal bundle. to olivary peduncle and fillet. to formatio reticularis.
Lateral column.	1. Crossed pyramidal tract.	to the inner part of the pyramid of opposite side.
	2. Direct lateral cerebellar tract.	to restiform body and thence to the cerebellum.
	3. Mixed zone.	to olivary fillet. to formatio reticularis. to fasciculus teres (Turner).
Posterior column.	1. Postero-internal strand.	to funiculus gracilis.
	2. Postero-external strand.	to funiculus cuneatus. to formatio reticularis.

Funiculus of Rolando not represented in white matter of the cord.

Arciform fibres.

3. GREY MATTER OF THE MEDULLA.

From the white strands of the medulla, which have so far occupied our attention, we next turn to the consideration of the arrangement of its grey substance. This is far more irregular than that of the spinal cord, and for its satisfactory study you will require a special series of preparations, though it is hoped the accompanying figures will give you material assistance.

The grey matter of the medulla oblongata may be described under two heads—(1.) that represented in the spinal cord, and derived from one or other of its grey cornua; (2.) that not so represented, but forming isolated collections or nuclei not connected with the grey matter of the spinal cord.

i. **Grey Matter derived from the Grey Crescents.**—Transverse sections of the lower part of the medulla will show you that the grey matter has an arrangement very similar to that of the grey matter of the spinal cord (fig. 36 and 37, p. 54); but that higher up in the medulla the appearance of the grey crescents becomes much changed (fig. 38).

(*a.*) The *anterior* cornu of the spinal cord loses its characteristic shape, and owing to the fibres of the crossed pyramidal tract, cutting their way through the neck of the anterior horn, the head becomes separated from the base, and the neck is replaced by a reticulum of fibres, part of the formatio reticularis. The *head* of the horn, thus detached, enlarges, and, by the formation of the anterior pyramids between it and the anterior median fissure, is pushed from the antero-lateral aspect of the cord to the lateral aspect of the medulla, where it may be seen in sections of the lower part of the medulla as a distinct grey collection, the NUCLEUS LATERALIS (fig. 37, n.l.).

Again, when the canal of the cord opens out into the floor of the 4th ventricle it brings the grey matter which surrounds that canal, to the surface, and hence the *base* of the anterior horn appears on the ventricular floor as a narrow grey tract close to the median furrow (fig. 33). It is known as the NUCLEUS OF THE FASCICULUS TERES or nucleus of the hypoglossal nerve.

The greater part of the anterior horn, the *neck*, is replaced, as above said, by a reticulum of cells and fibres, part of these latter being the fibres of the crossed tract on their way to the opposite side of the medulla. This network constitutes the anterior part of the formatio reticularis or RETICULARIS GRISEA (grey reticulum), (fig. 37, f.r.).

(b.) The grey matter of the *posterior* horn also takes a lateral position on reaching the medulla, and increases much in amount. The *head* of the horn, much enlarged, comes nearer to the surface, and appears at about the middle of the medulla as a well-marked grey nucleus, the TUBERCLE OF ROLANDO, (fig. 37, t.r.) beneath the surface prominence of the same name.

The grey matter of the *base* of this horn, also much increased in amount, forms between the median line and the grey nucleus of Rolando, two superficial aggregations, the inner one being the NUCLEUS OF THE FUNICULUS GRACILIS, the outer the NUCLEUS CUNEATUS (fig. 37 and 38), each lying beneath the corresponding white tract on the surface.

The *neck* of the posterior cornu, like that of the anterior, is replaced by a network, the RETICULARIS ALBA, which becomes continuous with the grey reticulum, constituting together the **Formatio Reticularis** (figs. 37 and 63),—a network of longitudinal, oblique, and transverse fibres, with nerve cells and neuroglia cells embedded amongst them. The fibres are chiefly commissural in nature, though there are reasons for thinking that sensory impulses, and impulses which inhibit spinal reflexes pass through this reticulum. Its longitudinal fibres are derived from the mixed zone of the lateral column, and probably also from the mixed zone (anterior root zone) of the anterior column of the spinal cord. The funiculus gracilis and the funiculus cuneatus can also be traced through this reticulum to the cerebrum (fig. 63).

ii. **Isolated Grey Masses or Nuclei of the Medulla.**—(1) The chief of these, the CORPUS DENTATUM or OLIVARY NUCLEUS (fig. 38), is contained in the centre of the olivary body, and is covered superficially by the external arciform fibres. This ganglion consists of flask-shaped, multipolar nerve cells, and neuroglia cells arranged as a zigzag lamina or crumpled sheet of grey matter concave and open in its inner aspect. Though this opening, called the *hilus*, passes the olivary peduncle, a bundle of nerve fibres, which, after having decussated in the middle line, passes from the anterior area of the medulla, and enters the centre of the olivary nucleus, to be there distributed in different directions,—I. some of the fibres end in the nerve cells of the grey lamina; II. some go through the lamina, and can be traced to the restiform body and cerebellum under the name of the internal (or deep) arciform fibres; III. others make to the surface, and there join the superficial (external) arciform fibres, and go along with them and the direct lateral cerebellar tract to the restiform body.

The olivary ganglion is closely connected with the corpus dentatum of the cerebellum, for any injury to

PLATE 10.

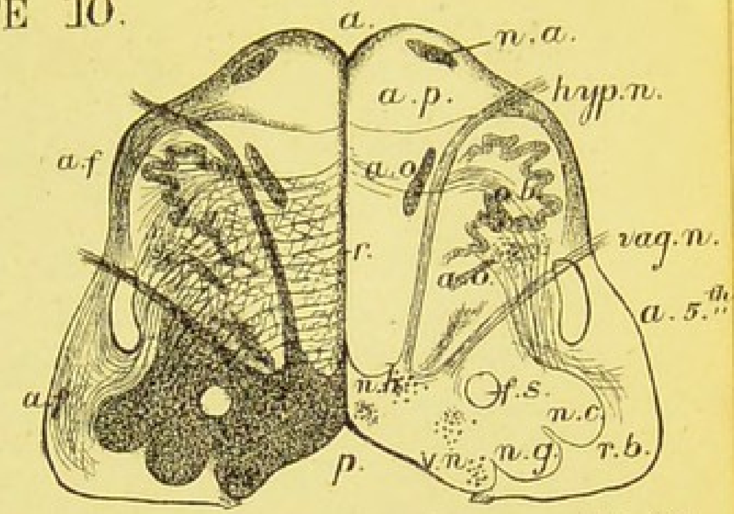

Fig. 38.

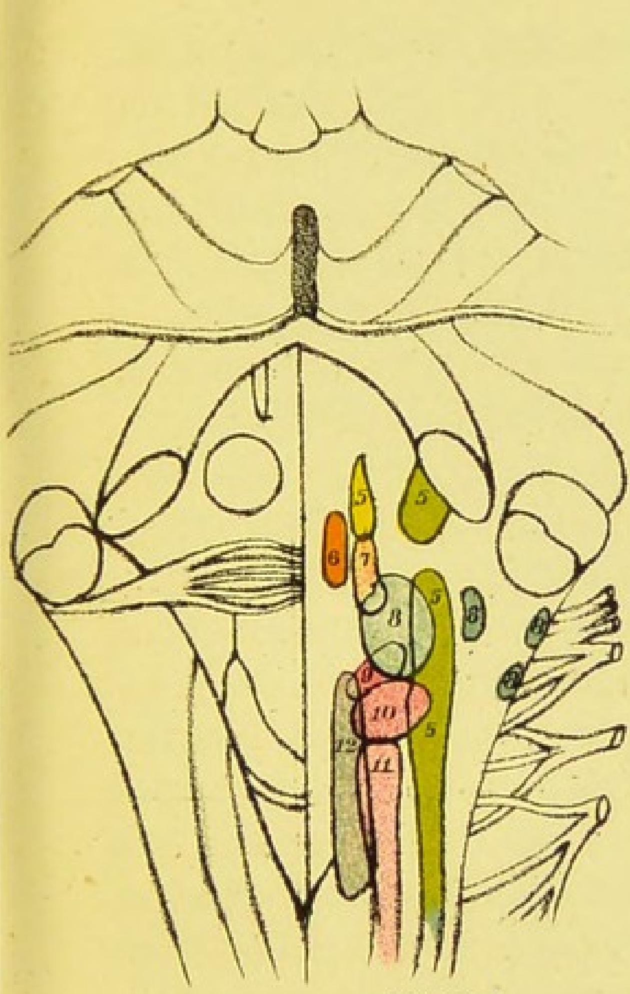

Fig. 34.

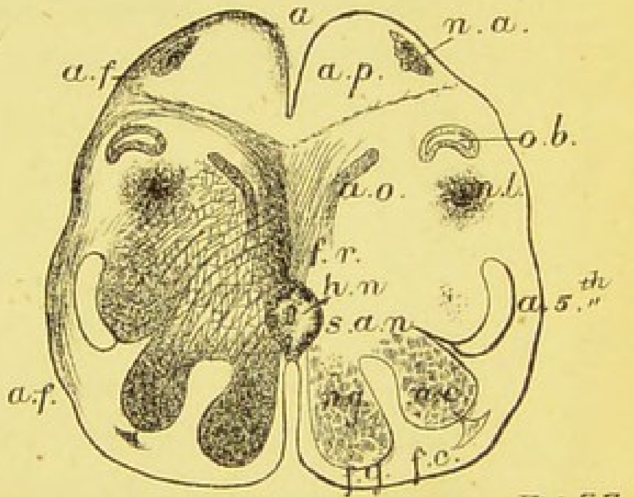

Fig. 37.

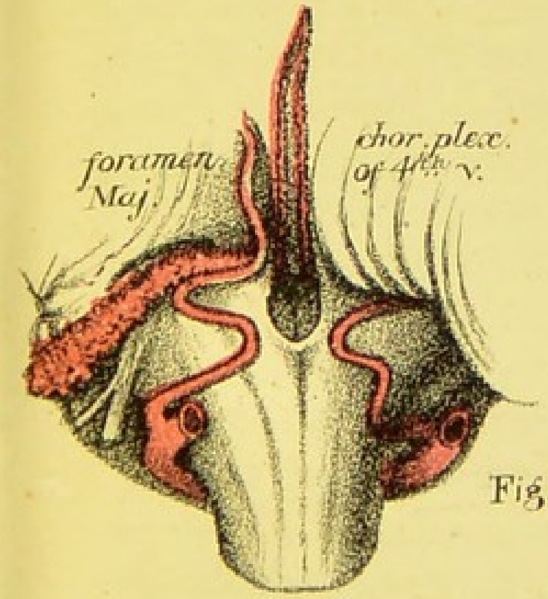

Fig. 35.

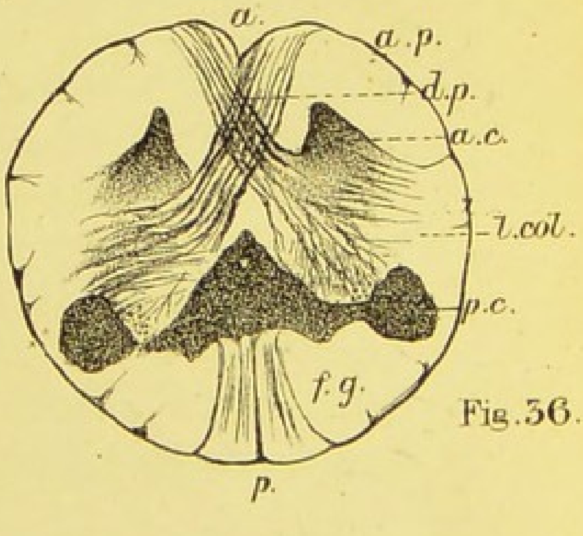

Fig. 36.

this latter nucleus causes atrophy of the olivary ganglion (fig. 63, a.f., p.).

(2.) Two other isolated nuclei are the accessory olives (fig. 38, a.o.), the one on the inner side of, the other behind, the corpus dentatum. They are linear in shape, and are closely connected with the olivary nucleus.

(3.) The third nucleus is that of the external arciform fibres (fig. 38, n.a.), placed amongst these fibres as they cross over the anterior pyramids of the medulla.

Raphé.—The medulla is partially divided into two lateral segments by a central median raphé or partition, which forms a thin membranous septa of nerve substance, extending from the anterior median fissure to beneath the central groove on the floor of the 4th ventricle. It consists of numerous fibres running in various directions, and interspersed with small collections of multipolar nerve cells.

The **Arciform Fibres** have already been several times alluded to, so that here we shall merely collect together, for the sake of clearness, the several statements previously made. These fibres are divided into a superficial and a deep set.

(1.) The SUPERFICIAL ARCIFORM FIBRES (fig. 37), you will remember, spring from the anterior median fissure, through which they can be traced to the central raphé, where they probably cross over to the opposite side of the medulla. Emerging from the fissure, they pass over the anterior pyramids below, and over the outer surface of the olives, across the line of origin of the 8th pair of nerves. Turning upwards, they then blend with the fibres of the direct lateral cerebellar tract, and with them form the Restiform Body (fig. 33, a.f., p. 48).

(2.) The DEEP ARCIFORM FIBRES (fig. 38, d.a.t.) also arise in the central raphé, and, passing into the centre of olivary nucleus through its hilus, join the cells of that nucleus, or pass through it to the restiform directly, or else first make to the surface, and then along with the external arciform fibres, go to the restiform body. Some are said to go to the nucleus cuneatus and to the nucleus of the funiculus gracilis.

TABLE OF GREY MATTER OF THE MEDULLA.

	Cord.	Medulla.
Grey matter of the Spinal Cord.	Anterior cornu.	Head—Nucleus lateralis. Neck—Anterior part of the formatio reticularis. Base—Nucleus of the fasciculus teres.
	Posterior cornu.	Head—Nucleus of Rolando. Neck—Posterior part of the formatio reticularis. Base—Nucleus of the funiculus gracilis. Nucleus cuneatus. Nuclei on floor of 4th ventricle

Isolated grey nuclei in the medulla.	Nucleus of the olivary body. Accessory olivary nuclei. Nucleus of the external arciform fibres.

RECAPITULATION.—Since the constitution of the medulla is so complicated, it will be well to summarise the above facts in a somewhat different order. Commencing at the anterior median fissure, we first meet, on each side of that fissure—(1) THE ANTERIOR PYRAMIDS OF THE MEDULLA, composed of longitudinal fibres, derived chiefly from the crossed pyramidal tract of the opposite lateral column, and of the direct pyramidal tract of the same side; they can be traced upwards through the cerebral peduncles to the cerebral hemispheres, and probably all the motor fibres coming from the brain are contained in these pyramids.

(2.) Superficial to the anterior pyramids are a set of fibres, which, having decussated in the middle line, pass out from the anterior median fissure, cross over the surface of the anterior pyramids and the olives to join the restiform body. They are the SUPERFICIAL ARCIFORM FIBRES (figs. 33 and 38), and amongst them is the ARCIFORM NUCLEUS, by some regarded as grey matter, by others as neuroglia and blood-vessels.

(3.) Behind the pyramids lies a reticulum of commissural fibres with nerve cells and neuroglia cells, the FORMATIO RETICULARIS (reticularis alba and grisea) (fig. 37 and 38, f.r.).

(4.) Outside the formatio reticularis, between it and the surface, and behind the pyramids, is the OLIVARY NUCLEUS with the OLIVARY PEDUNCLES (fig. 38). This nucleus is covered superficially by the external arciform fibres (fig. 38), and close to it are the ACCESSORY OLIVES (fig. 38).

(5.) Behind the olives you will see the NUCLEUS LATERALIS (fig. 37, n.l.), the upward continuation of the anterior cornu of the spinal cord.

(6.) Behind the nucleus lateralis appears the grey TUBERCLE OF ROLANDO (fig. 37 and 38, t.r.), the enlarged head of the posterior horn of the spinal cord. It gives origin to the sensory fibres of the 5th nerve, which will be seen in section, as a white concave band on its outer side (fig. 38, a.s.). Superficial to the tubercle of Rolando are the fibres of the DIRECT LATERAL CEREBELLAR TRACT (fig. 33) on their way, along with the arciform fibres, to the inferior cerebellar peduncles (Restiform body).

(7.) Posterior and internal to the nucleus of Rolando is a mass of grey matter, the NUCLEUS CUNEATUS (fig. 37 and 38, n.c.), lying beneath the cuneate tubercle; and still nearer the middle line is another grey collection, the NUCLEUS of the FUNICULUS GRACILIS (fig. 37 and 38).

In front of the nucleus cuneatus will be seen a special white rounded fasciculus, probably the root of the phrenic nerve in the medulla. It is known as the FACICULUS SOLITARIUS (fig. 38, f.s.).

The rest of the grey matter, internal to the nucleus of the funiculus gracilis, and on each side of the posterior median groove, belongs to the floor of the 4th ventricle (fig. 34, page 54), and will be fully described with that cavity.

II. PONS VAROLII.

The **Pons Varolii**, when looked at from below, appears as a broad white band crossing transversely in front of the upper part of the anterior surface of the medulla oblongata, between the two halves of the cerebellum. Composed of grey and white matter, it presents an upper and a lower border; an anterior and a posterior surface. The *upper border* is arched, and from it springs the two crura cerebri or cerebral peduncles; the *lower border*, which marks the upper limit of the medulla in front, is horizontal, and in contact with the upper margin of the pyramids and the olives.

The ANTERIOR SURFACE of the pons is convex, rests on the dorsum sellæ of the sphenoid bone, and along the middle line presents a shallow groove which lodges the basilar artery. At the sides it becomes narrowed, and passes as two rounded bundles, one on each side, into the cerebellum, forming its MIDDLE PEDUNCLES.

The POSTERIOR SURFACE of the Pons has ill-defined limits. Flattened from before backwards it forms the upper part of the floor of the 4th ventricle, and will be described with that cavity (page 69).

It is interesting to note that in mammalia the size of the Pons bears a direct relation to the size of the lateral lobes of the Cerebellum; and that in birds, reptiles, and fishes, where we have no cerebellar hemispheres, the Pons also is wanting.

I. WHITE MATTER OF THE PONS.

DISSECTION.—To see the arrangement of the white fibres of the Pons, you will require to cut down on each side the middle line, through the superficial transverse fibres, until you reach a longitudinal set passing upwards from the medulla. Reflect the longitudinal fibres when a still deeper transverse set will come into view. Fig. 32, page 44 will help you in making this dissection.

The white (medullated) nerve fibres of the Pons are arranged in two sets, a transverse and a longitudinal, each being again divisible into a superficial and a deep group.

(a) The **Superficial Transverse** fibres appear on the surface of the Pons, and the **Deep Transverse**

fibres lie behind the superficial longitudinal (fig. 39 and 40, page 60). At the lower part of the medulla the deep set of transverse fibres forms a special collection, called, from their peculiar arrangement, the *trapezium* (fig. 39). Traced laterally, all the transverse fibres pass into the middle peduncle of the cerebellum.

(b) The **Superficial Longitudinal** fibres (fig. 39, p.y.) are the upward continuation of the anterior pyramids of the medulla, and in transverse sections are seen as two rounded bundles, behind the superficial transverse fibres, though many of them are seen to intersect these latter. The **Deep Longitudinal** bundles (fig. 39, p.y.) are placed near the dorsal aspect of the Pons, which is chiefly made up of the formatio reticularis, and of a prolongation of the grey matter of the medulla.

This longitudinal set of fibres is said to be derived from the olivary fillet, from the olivary fasciculus, and from the lateral and posterior columns of the spinal cord.

2. Grey Matter of the Pons.

The grey matter of the Pons consists of multipolar and stellate nerve cells, either scattered or arranged in definite groups called nuclei. Thus we have—

i. The **Nucleus Pontis** (fig. 39), situated on the ventral aspect of the Pons, amongst the superficial transverse fibres, some of which are connected with its nerve cells.

ii. The **Superior Olivary Nucleus** (fig. 39, s.o.), placed on the dorsal part of the Pons, behind the trapezium and some little distance from the middle

PLATE II.

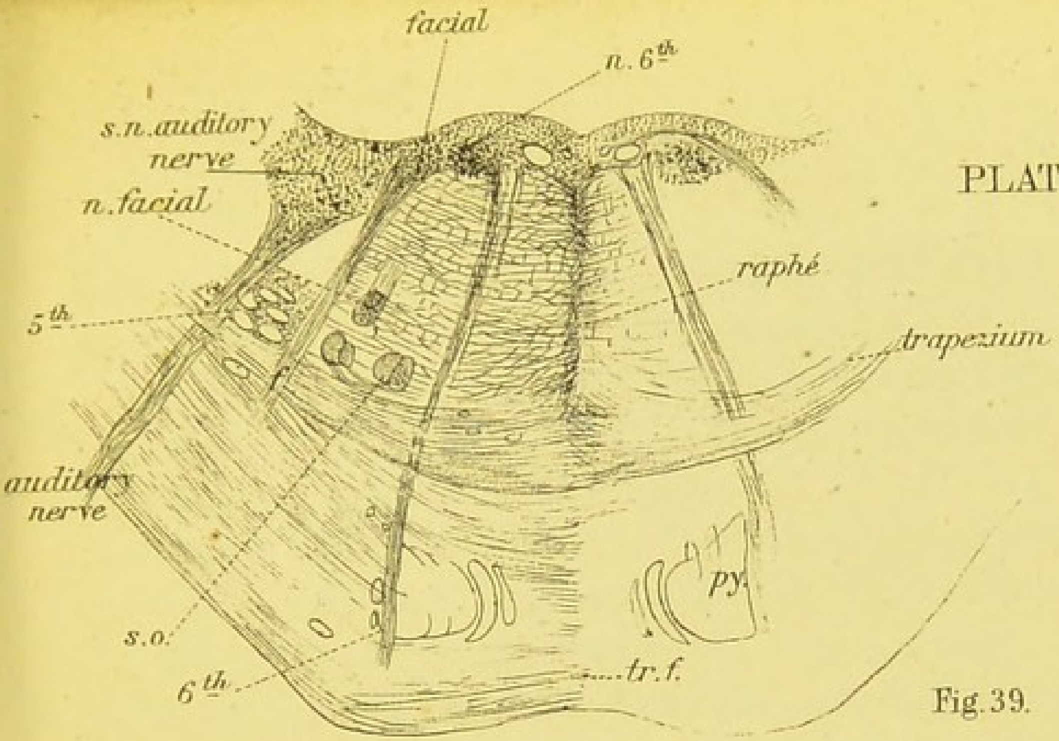

Fig. 39.

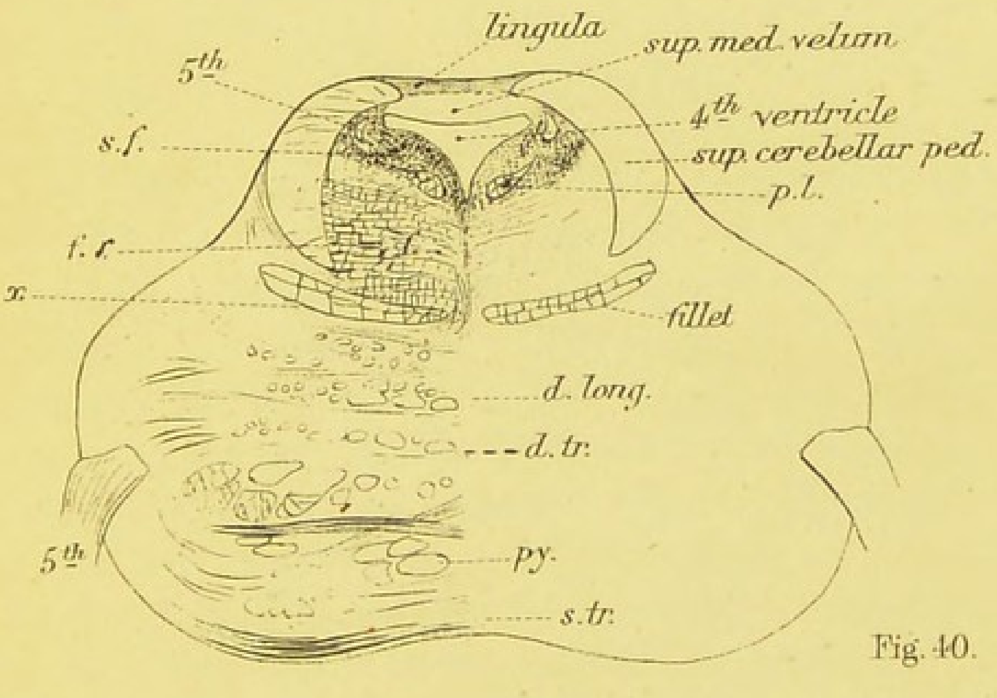

Fig. 40.

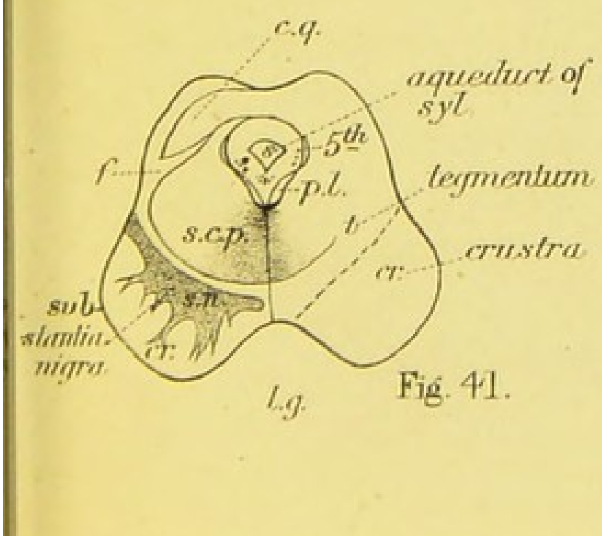

Fig. 41.

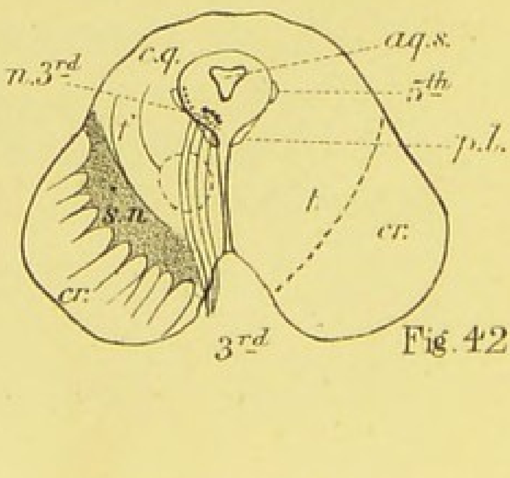

Fig. 42.

line, in a region which would correspond to the prolongation of the lateral area of the medulla.

iii. The **Nuclei of Origin** of some of the cranial nerves, which will be described with the upper part of the floor of the 4th ventricle (page 69).

Raphé of the Pons.—Behind the trapezium, and beneath the median groove on the floor of the 4th ventricle, lies a central raphé (fig. 39, r.), the continuation of the raphé of the medulla, and like it composed of fibres partly nervous and partly neuroglia, which cross each other in every direction.

III. CEREBELLUM.

The **Cerebellum** or Little Brain occupies the two lower fossæ of the occipital bone, and lies beneath the level of the tentorium cerebelli, which separates it from the cerebral hemispheres. Ellipsoidal in shape, it consists of a median division, called, from its worm-like appearance, the VERMIFORM PROCESS, and of two lateral divisions, the CEREBELLAR HEMISPHERES. The median division (the vermiform process) is quite a separate division of the little brain. This is shown by the fact that it is the only part of cerebellum which is developed in birds, in reptiles, and in fishes. Even in many mammals the central lobe is much larger than the lateral ones.

The CEREBELLAR HEMISPHERES present two surfaces, an upper and a lower, separated from each other by a definite margin, round which runs a well-marked cleft, the GREAT HORIZONTAL FISSURE. They are darker in colour than hemispheres of the cerebrum, and consist of numerous crescentric laminæ of grey matter with their convexities backwards.

The UPPER SURFACE of each cerebellar hemisphere is concave, but along the middle line runs a slightly raised ridge, indicating the position of the SUPERIOR VERMIFORM PROCESS. On this aspect the two hemispheres are continuous with each other across the middle line, there being no definite line of demarcation between them. The UNDER SURFACE of the hemispheres, on the other hand, is divided into two lateral convex halves by a wide median groove or hollow, the VALLECULÆ, in which you will see the INFERIOR VERMIFORM PROCESS. Posteriorly, the hemispheres are separated by a notch, INCISURA CEREBELLI POSTERIOR; which receives the free anterior margin of the falx cerebelli, and in front is a wider notch, the INCISURA CEREBELLI ANTERIOR, which lodges the Pons Varolii and Medulla.

1. LOBES OF THE CEREBELLUM.

The surfaces of the cerebellar hemispheres have a laminated appearance, for they are broken up by numerous furrows into crescent-shaped folia, which have been grouped together under special names, though it must be confessed that the lobes they form are often exceedingly ill-defined, and of little or no practical importance. A tabular list of them is here given for the purposes of reference.

(1.) On the **upper surface** of the cerebellar hemispheres are—

(a) The CENTRAL LOBE (fig. 43, l.c., page 64), situated near the centre of the anterior margin, and consisting of a few folia, which are continued upwards on to what is known as the superior vermiform process, to be presently described.

(*b*) The ANTERIOR-SUPERIOR (fig. 43, a.s.), and (*c*) the POSTERIOR-SUPERIOR (fig. 43, p.s.) LOBES are separated from each other by a more or less distinct sulcus, which arches transversely across the surface of each hemisphere. The anterior superior is often called the QUADRATE LOBE, and is divided into an anterior portion named the ANTERIOR CRESCENTRIC, and a posterior portion, the POSTERIOR CRESCENTRIC (fig. 43, a.c., p.c.). Each of these lobes is continuous across the superior vermiform process with the corresponding ones on the opposite side.

(2.) On the **under surface** of the hemispheres the lobes are better marked, and more easily distinguished than those of the upper surface. Enumerated from behind forwards they are:—

(*a.*) The POSTERIOR INFERIOR LOBE,		fig.	44.
(*b.*) The SLENDER	"	fig.	"
(*c.*) The BIVENTRAL	"	fig.	"
(*d.*) The AMYGDALOID	"	fig.	"
(*e.*) The FLOCCULUS		fig.	"

(3.) On the **Superior Vermiform Process** the lobes are an anterior, the LOBULUS CENTRALIS; a middle, the MONTICULUS CEREBELLI; and a posterior or COMMISSURA SIMPLEX.

(4.) On the **Inferior Vermiform Process**—

(*a.*) The TUBER VALVULÆ (fig. 44,t.v.), placed between the posterior superior and the slender lobes of opposite sides.

(*b.*) The PYRAMID (fig. 44, p.) between the biventral lobes.

(*c.*) The UVULA (fig. 44, u.) between the tonsils, and connected with them by a grey band, called, from its ridged appearance, the FURROWED BAND (fig. 44, f.b.).

(*d.*) The NODULE (fig. 44, n.) or LAMINATED TUBERCLE, the pointed anterior end of the inferior vermiform process. It is placed between the flocculi, and, projecting into the roof of the 4th ventricle, is continuous with the inferior medullary velum (page 66).

2. PEDUNCLES OF THE CEREBELLUM.

The **Peduncles of the Cerebellum** are three for each hemisphere, the superior, the middle, and the inferior. They connect the cerebellum (I.) to the pons, crura ad pontem; (II.) to the medulla, crura ad medullum; and (III.) to the cerebrum, crura ad cerebrum.

i. The **superior peduncles** (fig. 30, s.p., page 44) are hidden beneath the anterior part of the cerebellum, and to see them you will require to divide the cerebellum by a vertical median incision, and to draw the parts asunder. The crura ad cerebrum or superior peduncles arise in the middle of the white substance

PLATE 12.

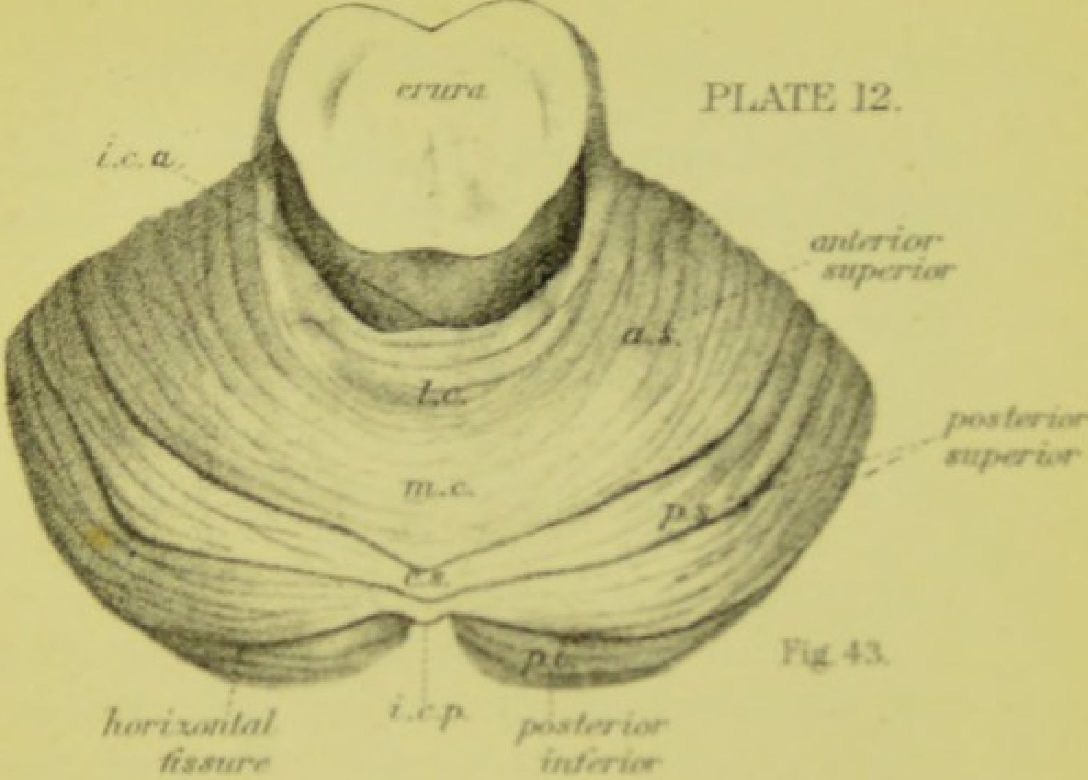

Fig. 43.

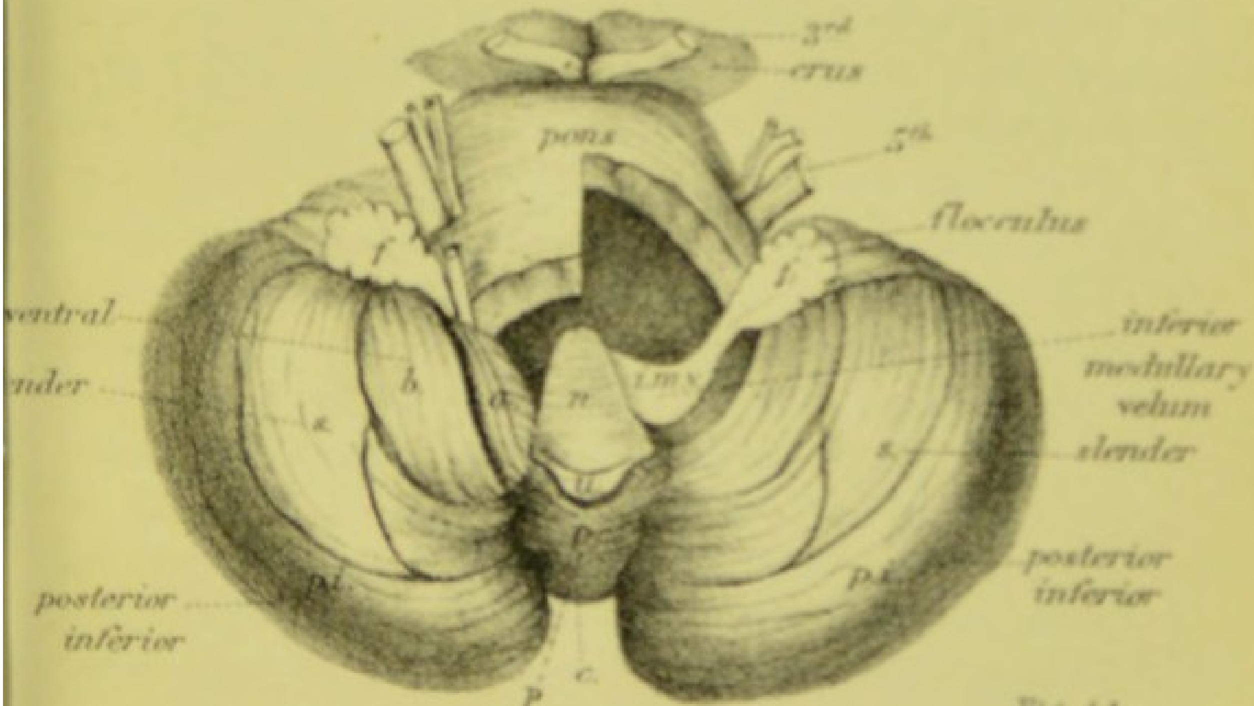

Fig. 44.

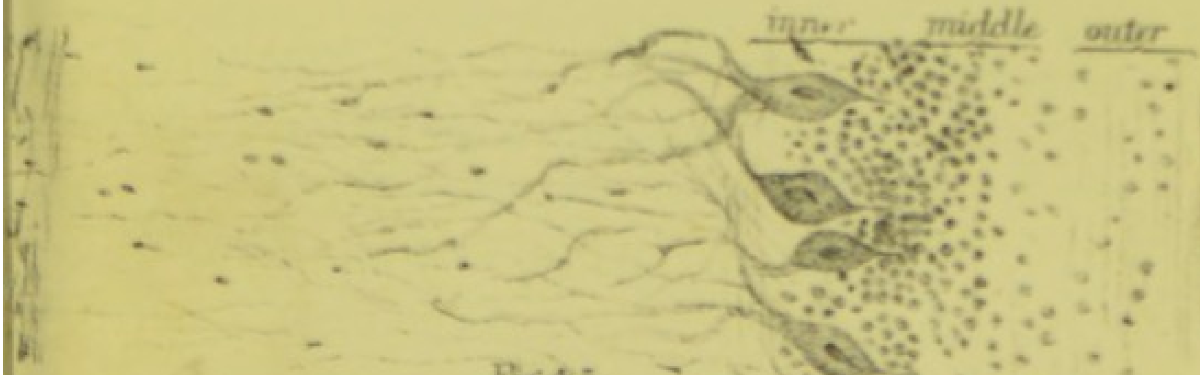

Fig. 45.

of the hemispheres, behind the inferior cerebellar peduncles, and running upwards and forwards to the under surface of the corpora quadrigemina, pass to the dorsal part of cerebral peduncles. The fibres of which they are composed come from the corpus dentatum of the cerebellum (fig. 63, s.p., page 114), and go to the higher parts of the brain (see page 112). At first the superior peduncles form the lateral wall of the upper part of the 4th ventricle, leaving a triangular interval between them which is bridged over by a lamina of nerve substance, the SUPERIOR MEDULLARY VELUM (fig. 58, s.m.v., page 98). They then meet in the middle line above, and form part of the roof of the 4th ventricle.

(ii.) The **middle peduncles** (fig. 29 and 30, m.p., page 44) of the cerebellum, crura ad pontem, are best seen in front, where they form two transverse white bands between the cerebellar hemispheres. Emerging from the lateral part of the white centre of the hemispheres, in front of the inferior peduncles, they pass towards the middle line and form the superficial and deep transverse fibres of the pons Varolii.

(iii.) The **inferior peduncles** (fig. 30 and 31, i.p., page 44) of the cerebellum, crura ad medullam, or restiform bodies, constitute one of the boundaries of the lower part of the 4th ventricle, and then pass upwards between the superior and middle peduncles into the white matter of the cerebellar hemispheres.

Thus it will be seen that the peduncular fibres, along with commissural bands passing from one hemisphere to the other, constitute the entire white core of the cerebellum.

3. Medullary Vela.

(i.) The **Superior Medullary Velum**—Valve of Vieussens (fig. 58, s.m.v., page 98)—is a delicate sheet of nerve substance placed across the triangular interval left between the superior cerebellar peduncles before they meet in the middle line. It consists of a white lamina crossed on its upper surface by several transverse grey ridges, with intervening furrows, called the LINGULA (fig. 40, ling., page 60), not to be confounded with the LIGULA (fig. 31, lig., page 44), the epithelial thickening along the lower margin of the 4th ventricle. The white and grey matter of the superior medullary velum are continuous at the sides with the white and grey matter of the cerebellar hemispheres.

(ii.) The **Inferior Medullary Velum**—Valve of Tarini (fig. 44, i.m.v., page 64).—In order to see this velum you must remove the amygdaloid lobes. Consisting of two thin white lamina of nerve substance semilunar in shape, this velum stretches between the two flocculi to which it is attached externally. Internally, on the other hand, the two parts of the velum are united to the under surface of the nodule, and are continuous with each other beneath it. The inferior convex margins of each division blends with the white substance of the inferior vermiform process, and with the furrowed band; their free concave upper (or anterior) margins are continuous with the epithelium which lines the under surface of the pia mater roofing over the lower part of the 4th ventricle.

4. Grey Matter of the Cerebellum.

(a) The grey matter of the *cortex* of the cerebellum not only covers its surface but lines the sides and passes across the bottom of its various fissure or sulci, so that in reality it forms a thin lamina folded on itself in a series of leaves or plates. A mesial vertical section will enable you to see this arrangement, and will show you the beautiful tree-like appearance, ARBOR VITÆ, of the grey and white matter (fig. 27, page 38, and fig. 58, page 98).

(b) The chief mass of grey matter in the *interior* of the hemispheres is the CORPUS DENTATUM (fig. 63, c.d., page), similar in structure to the corpus dentatum of the olivary body, and, as you will remember, closely connected with it. It consists of a wavy band of brown coloured nerve substance enclosing white matter, the whole forming a pouch-like wavy lamina or capsule open at its upper and inner side. Through this opening, bundles of white nerve fibres pass into the centre of the corpus dentatum, and can be traced from the superior cerebellar peduncles, from the superior medullary velum, and from the olivary body.

The other nuclei of the cerebellum are of minor importance, and are named the nucleus globosus, emboliformis, and fastigii.

MINUTE STRUCTURE OF THE GREY MATTER OF THE CEREBELLUM.—The grey cortex of the cerebellum consists of three layers, an outer, an inner, and a middle layer (fig. 45, page 64).

(*a*.) The **outer layer** (fig. 45) forms a clear grey stratum chiefly composed of a delicate matrix of neuroglia, with nerve cells and nerve cell processes.

(*b.*) The **inner layer**, called the **granular** layer (rust coloured, Turner), (fig. 45), consists of nucleated corpuscles, rounded or angular in shape, and embedded in a matrix of fine interlacing nerve fibrillæ.

(*c.*) The **middle layer** is formed of cells which are characteristic of the grey matter of the cerebellum. They are called the CELLS OF PURKINJE (fig. 45), or from their shape, ANTLER CELLS, and are large flask-shaped cells set at right angles to the surface of the cerebellum. Their larger ends are the deeper, and give off a single, slender, unbranched, process, which is probably connected with the cells of the innermost layer. Their outer process is much larger, and branches like the horns of a deer, hence the name antler cells; its branches are connected with the cells of the outer layer of the cortex.

The *white matter* of the cerebellum is composed of white medullated nerve fibres, which have nothing characteristic or distinctive in their structure.

The functions of the cerebellum are as yet unknown, but the classical experiments of Fluorens point to the fact that it is a centre for the co-ordination of muscular movements, such as walking, &c. Later experiments show that the cerebellum is an organ of equilibration.

THE 4TH VENTRICLE.

ITS POSITION, FLOOR, ROOF, WALLS, AND NUCLEI.

The 4TH VENTRICLE is a conical shaped space with a tent-like roof, directed backwards, and a quadrilateral floor, directed forwards. Placed between the Medulla and Pons in front and the Cerebellum behind, the 4th ventricle is lodged in the fore-part of the Valleculla on the under surface of the Cerebellum. We shall require to examine (1.) its floor; (2.) its lateral boundaries; (3.) its roof; (4.) its lining; (5.) the openings into it; (6.) its choroid plexus; and (7.) the various collections of grey matter or nuclei beneath the floor.

I. The **Floor** or **Anterior Wall of the 4th Ventricle** (fig. 30, page 44) is a diamond-shaped depression of the figure of an heraldic lozenge, and resembles two triangles placed base to base. Its lower part occupies the back of the Medulla; its upper part the back of the Pons; and its formation is due to the separation of the walls of the posterior median fissure of the spinal cord, and the consequent opening out of the central canal or ventricle of the cord, thus bringing the grey matter to the surface. Of its four angles two are lateral, right and left, and mark the widest transverse diameter of the floor; of the other two angles, the superior is on a level with the upper border of the Pons, the inferior with the lower border of the Olivary Body. From some supposed likeness to a writing pen the apex of the lower part of the ventricular floor has been called the "calamus scriptorius," a term that might well be discarded. At the lateral angles the space is prolonged for a short distance between the Cerebellum and Medulla, the prolongations being called LATERAL RECESSES (fig. 30, l.r., page 44, and fig. 33, l.r., page 48). Running across the widest part of the ventricular floor, opposite the lateral angles, are the STRIÆ ACUSTICÆ (fig.

30 and 33, s.a.), which, you will remember, mark the upper limit of the Medulla on this aspect. They also serve to divide the ventricular floor into two divisions, a lower or MEDULLA PORTION and an upper or PONS PORTION (fig. 33, p. 48), both of which are again subdivided by the vertical median groove that runs from the superior to the inferior angle into two lateral segments. Thus we get the entire ventricular floor marked out into four divisions, two above and two below the striæ acusticæ (fig. 33). On examining each of the lower divisions you will see, at about their centre, a small triangular depression called the INFERIOR FOVEA (fig. 33, i.f.), the base of which is directed downwards, the apex upwards and in close contact with the striæ; while its inner and outer margins are prolonged downwards as two grooves, the inner until it meets the central median furrow near the lower angle of the ventricle; the outer until it reaches the lateral wall of the cavity. Thus we find that each part of the medullary division of the ventricular floor can be mapped out into four distinct areas.

(1.) One enclosed within the sides of the triangular depression—THE INFERIOR FOVEA (fig. 30, page 44, and 33, i.f., page 48).

(2.) A raised area—FASCICULUS TERES—between the median furrow and the inner margin of the fovea (fig. 33, f.t.).

(3.) The TUBERCULUM ACUSTICUM lying between the lateral wall and the outer margin of the fovea (fig. 33, t.a.).

(4.) The ALA CINEREA with the EMINENTIA CINEREA placed below the base of the inferior fovea (fig. 33, a.c.).

In like manner each of the two upper segments of the ventricular floor will be found to be marked by a similar triangular depression (fig. 33, s.f.), THE SUPERIOR (ANTERIOR) FOVEA, between which and the central furrow is a prolongation of the fasciculus teres. Extending from the apex of this fovea to the upper angle of the ventricle is a shallow depression which, from its dark aspect, is called the LOCUS CÆRULEUS (fig. 30, l.c., page 44); the colour being due to a mass of pigment cells lying beneath.

2. **Lateral Walls of the 4th Ventricles.**—The boundaries of the lower half of the ventricular cavity are *(a)* the FUNICULUS GRACILIS and its CLAVA (fig. 31 and 33, cl.); *(b)* higher up the tapering end of the FUNICULUS CUNEATUS (fig. 31 and 33, f.c.); *(c)* and highest of all the RESTIFORM BODY or inferior peduncle of the cerebellum (fig. 31 and 33, r.b.); the boundary of the upper division of the floor is the SUPERIOR CEREBELLAR PEDUNCLES (fig. 30, s.p.).

3. **Roof of the 4th Ventricle.**—The lower half of the ventricular cavity is roofed over by a reflection of the pia mater from the Cerebellum to the back of the Medulla. It is, however, deficient in the middle line. Its under surface is lined by a layer of flattened epithelial cells, and a thickening of this epithelium at the lower angle of the ventricle is called the OBEX (fig. 31, page 44) and a similar thickening with the addition of a little white nervous matter skirting the side of the lower half of the floor is called the LIGULA

or TÆNIA (fig. 31, lig.). The roof of the upper portion of the ventricle is formed partly by the SUPERIOR CEREBELLAR PEDUNCLES after they meet in the middle line; and partly by the SUPERIOR and INFERIOR MEDULLARY VELA (fig. 58, page 98, s.m.v., and fig. 44, page 64, i.m.v.).

4. **Ependyma Ventriculorum.**—The floor of the 4th ventricle is covered by a layer of grey matter—the EPENDYMA VENTRICULORUM—consisting of neuroglia derived from the central grey nucleus round the canal of the spinal cord. Upon this ependyma lies a layer of epithelium cells continuous with the epithelium lining the central canal of the spinal marrow, and the other ventricles of the brain.

5. **Openings into the 4th Ventricle.**—At the superior angle the 4th ventricle communicates by a narrow channel, AQUEDUCT OF SYLVIUS (iter a tertio ad quartum ventriculum) with the THIRD VENTRICLE (fig. 58, page 98, glass rod through the passage); below at the inferior angle the cavity is continuous with the CENTRAL CANAL of the SPINAL CORD; behind at the lower part of the roof, just above the inferior angle, by a small rounded opening, the FORAMEN OF MAJENDIE (fig. 35, page 54, f.m.), with the SUBARACHNOID SPACE; while at each side, near the lateral angles, are similar openings in the roof, between the Cerebellum and Medulla and behind the roots of the glossopharyngeal nerve.

6. **Choroid Plexus** (fig. 35, c.p., page 54).—The choroid plexus of the 4th ventricle consists of two longitudinal vascular folds attached to the under surface of the pia mater over the roof of the 4th ventricle. These vascular fringes run along each side of the middle line

of the roof, projecting into the ventricle, though covered everywhere on their under surface, by the epithelium of the roof which follows all their windings and folds, and separates them from the cavity of the ventricle. Part of this plexus passes, as a vascular tuft, into each lateral recess.

7. **Grey Matter or Nuclei beneath the Floor of the 4th Ventricle.**—Connected with the grey matter of the floor of the 4th ventricle are certain physiological centres—such as the vaso-motor, respiratory, and cardiac—but besides these, as yet ill-defined centres, we have the nuclei of origin of several of the cranial nerves.

1. The first of these nerve nuclei—HYPOGLOSSAL (fig. 34, No. 12, page 54)—lies beneath the surface prominence known as the *fasciculus teres* skirting the median furrow on the ventricular floor. This nucleus, which not only occupies the lower part of this area, but also passes up under the striæ acusticæ, gives origin to the 9th nerve, and is hence called the HYPOGLOSSAL NUCLEUS.

2. The *Tuberculum Acusticum*, corresponding in position to the tubercle of Rolando, covers the PRINCIPAL AUDITORY NUCLEUS (fig. 34, No. 8, and fig. 33, page 48, t.a.), which, like the previous one, extends beneath the striæ into the upper division of the ventricular floor.

3. The *ala cinerea* and its *eminentia* contains the nuclei of origin of several nerves; thus, in its lower part, we have the nucleus of the SPINAL ACCESSORY NERVE (fig. 34, No. 11); in its upper part, and extending into the inferior fovea, are the NUCLEUS OF THE VAGUS below (fig. 34, No. 10), and of the GLOSSOPHARYNGEAL

above (fig. 34, No. 9). Beneath the upper division of the ventricular floor, close to the lateral recesses, are the SENSORY and MOTOR NUCLEI OF THE 5TH NERVE, the motor being internal, the sensory external (fig. 34, No. 5). The nucleus of the 6TH NERVE (fig. 34, No. 6) lies superficial to but higher up and nearer the middle line than the nucleus of the 7th; the 7TH (FACIAL part) is placed deeper, and internal to the 5th (fig. 34, No. 7), but external to the 6th nerve (fig. 34). The nucleus of the AUDITORY PART OF THE 7TH is external to the 6th nerve. These various nuclei will be again referred to in the section on the superficial and deep origins of the cranial nerves.

IV. THE CEREBRUM.

General Outline.—In man the CEREBRUM is by far the largest division of the brain, and weighs on an average from 46 to 53 oz. Above, it occupies the vault of the cranium; below, at its base, it is lodged in front within the anterior and middle cranial fossæ, but behind it rests on the upper surface of the tentorium cerebelli. An egg-shaped mass of nervous substance, it is larger behind than in front, and is partly separated by the great longitudinal fissure into two halves—the CEREBRAL HEMISPHERES—which are ovoid in shape and are composed of a white stalk or peduncle, surmounted by a convoluted grey crust, mapped out by furrows or SULCI into a series of larger or smaller folds called CONVOLUTIONS.

Internally the cerebrum consists of GANGLIONIC MASSES and COMMISSURES; and its centre is hollowed out into a large cavity subdivided by partitions into smaller spaces called VENTRICLES.

We shall describe—I. the EXTERIOR or cortex of the cerebrum with its FISSURES, LOBES, and CONVOLUTIONS; II. the BASE; and III. the INTERIOR with its VENTRICLES, GANGLIA, AND COMMISSURAL BANDS.

I. EXTERIOR OF THE CEREBRUM.

Each hemisphere presents three surfaces—an outer convex; a mesial, plane and vertical; and an under surface or base. We shall examine—(1) the Fissures; (2) the Lobes and Convolutions.

1. FISSURES OF THE CEREBRAL HEMISPHERES.

Of the **Fissures** of the hemispheres the largest and most evident subdivide the surface of the cerebrum into lobes, and may be called INTERLOBULAR; the smaller fissures—INTRALOBULAR—divide the lobes into convolutions, which, in most cases, have received definite designations.

(a.) The **Interlobular Fissures** are (1) the FISSURE OF SYLVIUS; (2) the FISSURE OF ROLANDO; (3) the PARIETO-OCCIPITAL FISSURE.

(1.) The **Fissure of Sylvius,** unlike the other sulci of the hemispheres, is not a mere indentation of the cerebral cortex, but is formed by the folding upon itself of the entire cerebral substance (see Chap. III). Beginning on the under surface of the hemisphere, at a point called the anterior perforated spot, this fissure runs upwards and outwards to the lateral aspect of the hemisphere, and there divides into two limbs, an anterior, *vertical*, and a posterior, *horizontal* (fig. 47, page 76).

(2.) **Fissure of Rolando** (figs. 46 and 47, page 76, f.R.), one of the first to appear in the development of the brain, commences above, close to, though rarely reaching the median longitudinal cleft, and then descends obliquely forwards across the outer surface of the hemisphere, to end below at the anterior part of the horizontal limb of the fissure of Sylvius.

(3.) The **Parieto-occipital fissure** appears on both the outer and inner surface of the hemisphere. The EXTERNAL PARIETO-OCCIPITAL FISSURE is a short cleft on the outer aspect of the hemisphere near its hinder end (fig. 46, par. occ.); the INTERNAL PARIETAO-OCCIPITAL FISSURE, continuous above with the external, is a very constant fissure, and descends vertically on the mesial aspect of the cerebrum (fig. 49, page 78, par. occ.), it will be noticed, with that surface of the hemispheres.

(b.) The **Intralobular Fissures** separate individual convolutions from each other.—Those which have received special names are—I. the præcentral (fig. 46, præ.cent.); II. intraparietal (fig. 46, int.par.); III. the parallel (fig 47, parll.); IV. the triradiate (fig. 48, tr.f.); V. the collateral (fig. 49, coll.f.); VI. the callosal (fig. 49, call.f.); VII. calloso-marginal (fig. 49, calloso-m.); VIII. the calcarine (fig. 49, cal.); and IX. the dentate (fig. 49, d.). They will be described with the convolutions which they serve to map out.

PLATE 15.

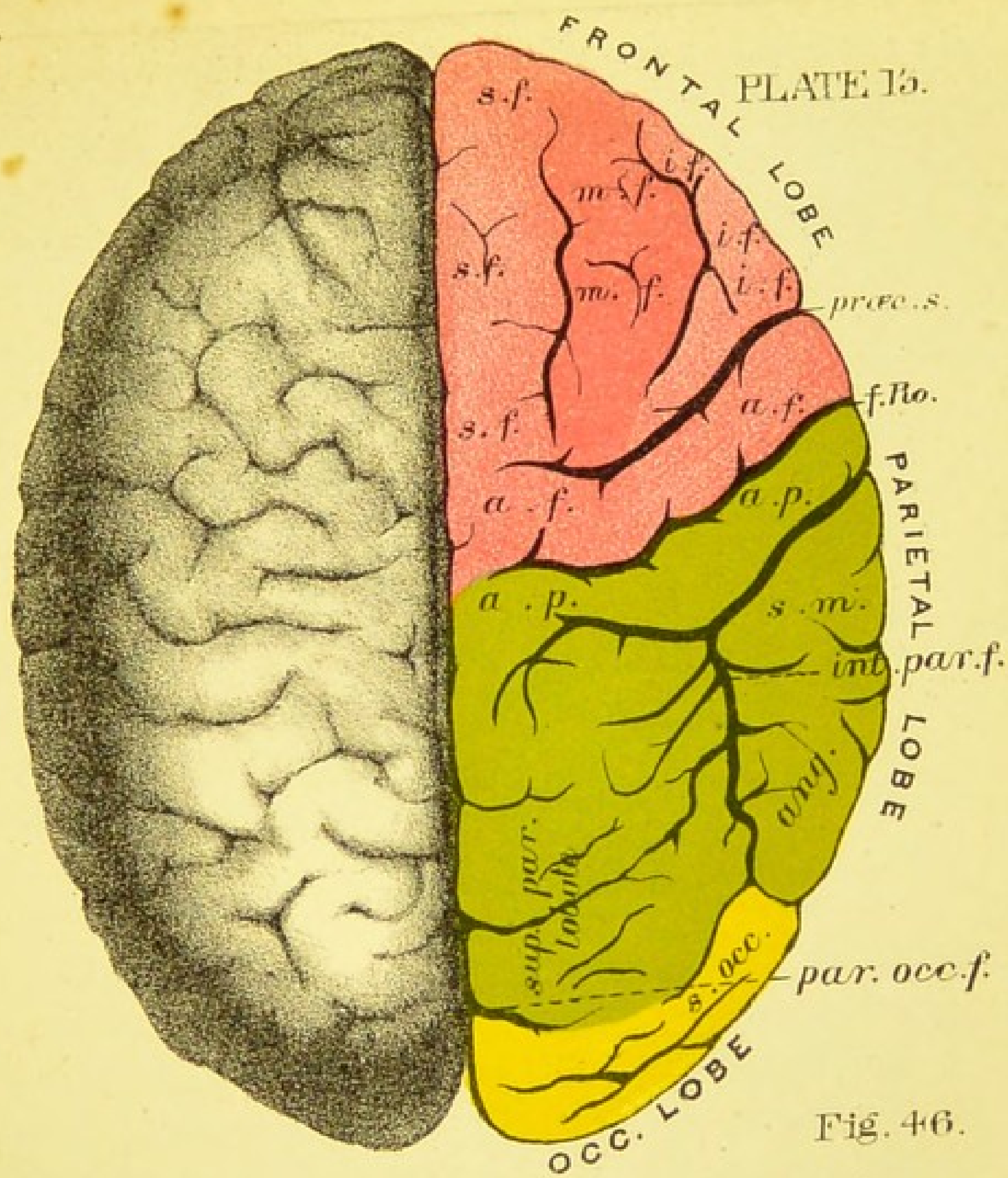

Fig. 46.

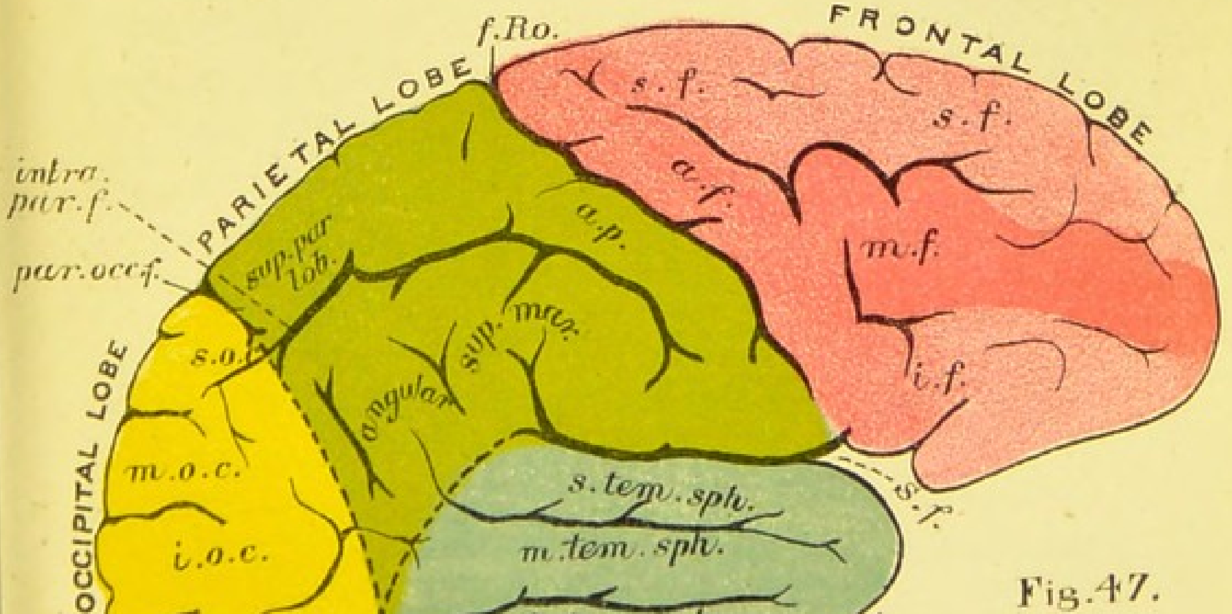

Fig. 47.

2. Lobes and Convolutions of the Cerebral Hemispheres.

The **Lobes** of the cerebrum are five in number; four are bounded by the interlobular fissures and take their names from the bones of the skull in relation to which they lie. They are (I) the FRONTAL; (II) the PARIETAL; (III) the OCCIPITAL; (IV) the TEMPORO-SPHENOIDAL. The fifth lobe—the CENTRAL LOBE—(Insula or Isle of Reil) is not in contact with the bones of the skull, but is hidden within the Fissure of Sylvius, the margins of which must be separated in order to see it.

I. The **Frontal Lobe** (fig. 46, 47, 48, pages 76 and 78)) is pyramidal in shape and is bounded behind by the FISSURE of ROLANDO which separates it from the Parietal lobe; below by the HORIZONTAL LIMB of the FISSURE of SYLVIUS which separates it from the Temporo-sphenoidal lobe; above, where it passes into the inner surface of the hemisphere by the GREAT HORIZONTAL FISSURE; and in the rest of its extent by the MARGINS of the HEMISPHERE. It has three surfaces—an *outer*, an *inner* or mesial, and an *inferior* or orbital.

The *outer surface* has four convolutions; one, the ASCENDING FRONTAL CONVOLUTION (figs. 46 and 47, a.f.), runs parallel to and in front of the fissure of Rolando, and is limited in front by the PRÆCENTRAL SULCUS (fig. 46 and 47, præ. cent.), behind by the FISSURE OF ROLANDO. The rest of the surface in front of this gyrus is mapped out by two transverse parallel sulci into three antero-posterior gyri—the

SUPERIOR, the MIDDLE, and the INFERIOR FRONTAL CONVOLUTIONS (fig. 46 and 47, s.m.i.f.), which have been classed together by Gowers under the term PRE-FRONTAL LOBE. The left inferior frontal convolution is often called Brocas' convolution and probably contains the centre for speech.

The *orbital surface* of the Frontal Lobe presents, at about its centre, a three-legged sulcus—the TRI-RADIATE FISSURE—which subdivides the surface into three gyri, an INTERNAL ORBITAL or GYRUS RECTUS (fig. 48, page 78, i.or.)· an ANTERIOR ORBITAL (fig. 48, a.or.); and an EXTERNAL ORBITAL (fig. 48, e.or.); all of which are mere prolongations, into this surface, of the convolution of the outer surface. Thus the superior frontal convolution passes into the gyrus rectus, the middle into the anterior orbital, and the inferior into the external orbital.

On the surface of the gyrus rectus is lodged, in a triangular sulcus—OLFACTORY GROOVE,—a club shaped body—the OLFACTORY BULB and its PEDUNCLE. Traced backwards the peduncle bifurcates behind into two white bands, the outer passing backwards towards the fissure of Sylvius where it is lost, the inner running to the side of the great longitudinal fissure (fig. 24, page 24). Between these two limbs you will see a small conical elevation—the OLFACTORY TUBERCLE, which is often looked upon as the middle root of the olfactory peduncle.

The *mesial surface* of the Frontal Lobe will be described with the corresponding surface of the hemisphere.

FRON

PLATE 14.

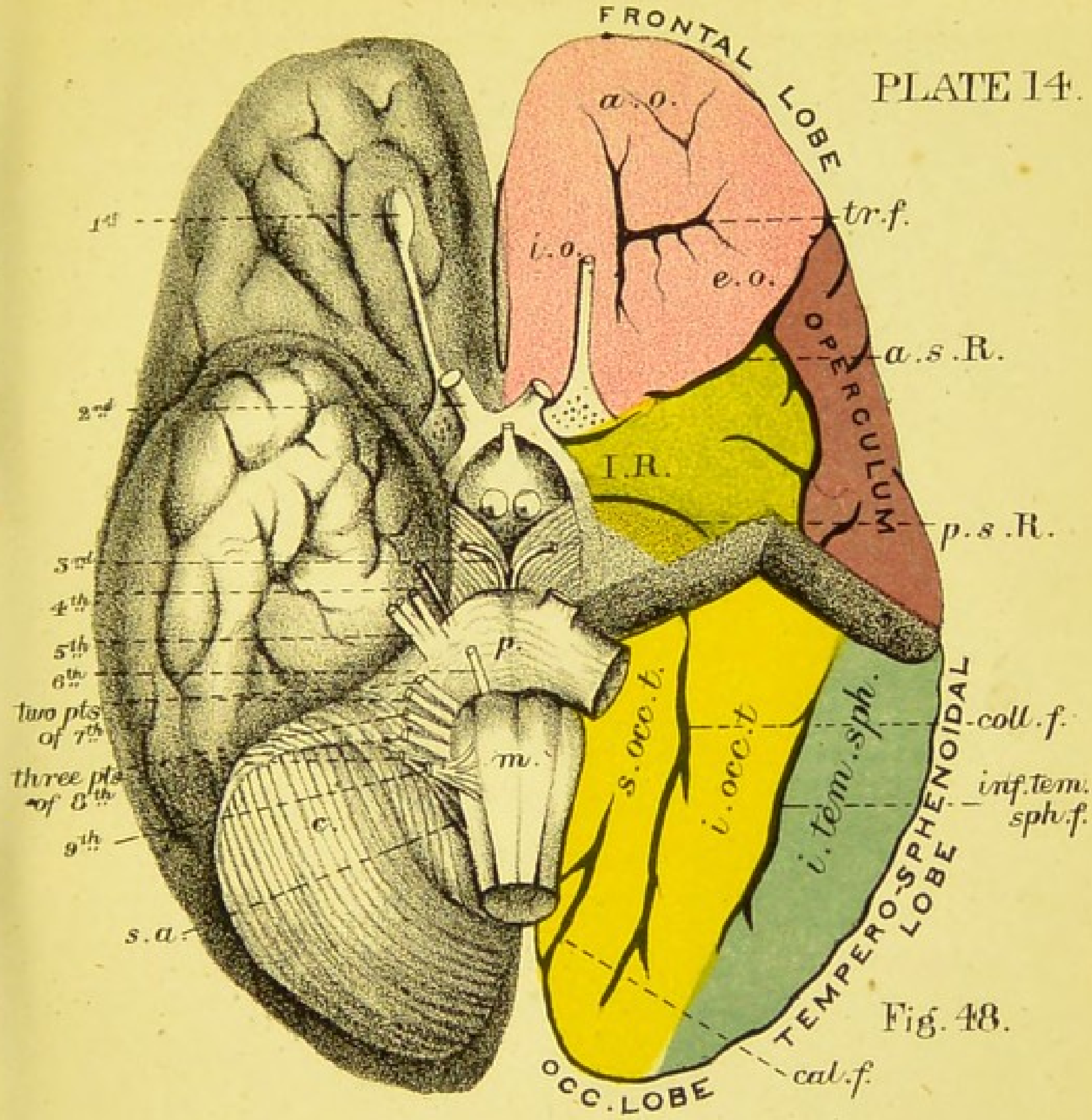

Fig. 48.

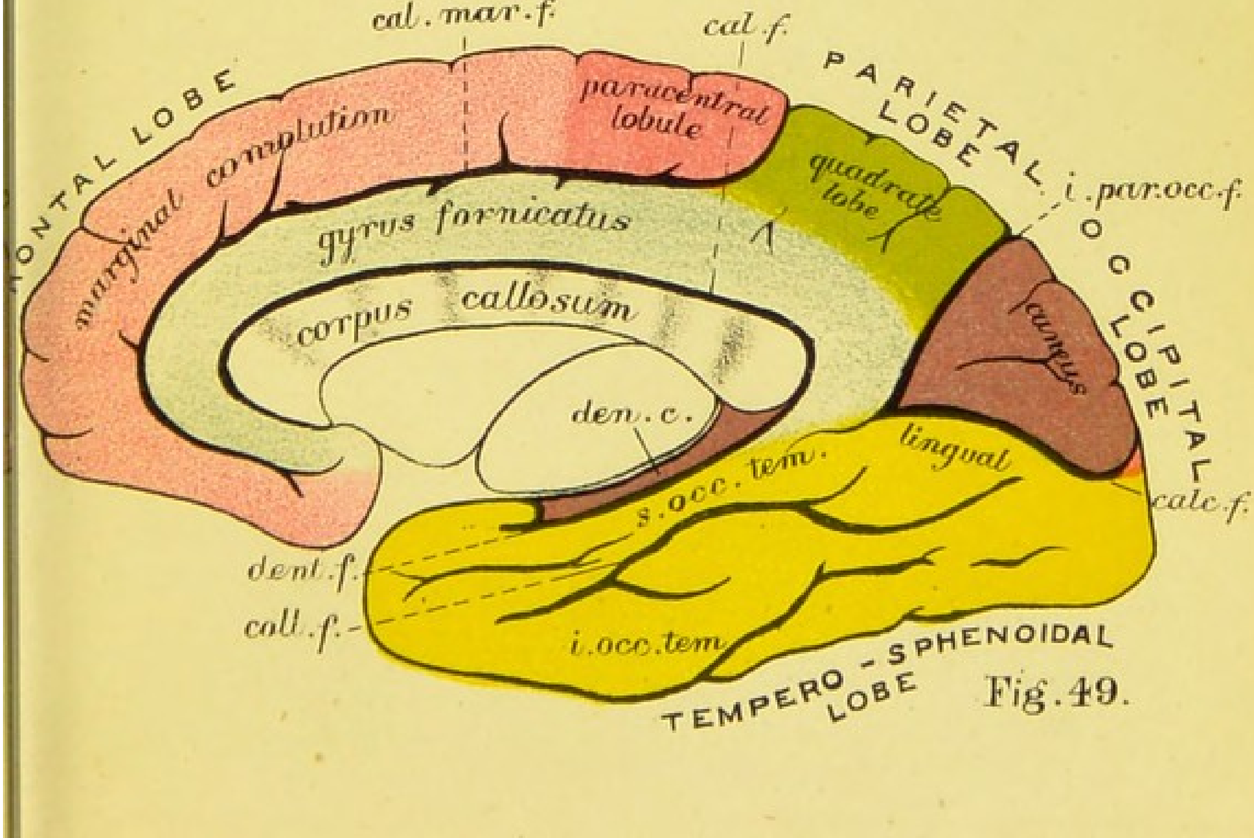

Fig. 49.

TABLE OF THE FRONTAL CONVOLUTIONS.

Frontal lobe.	Outer surface.	Ascending frontal. Superior frontal. Middle frontal. Inferior frontal.
	Inner surface.	See mesial surface of hemispheres.
	Lower surface.	Internal orbital (Gyrus rectus). Anterior orbital. External orbital.

II. The **Parietal Lobe** has an *inner surface* belonging to the inner aspect of the hemisphere (see mesial surface); and an *outer surface*, lateral and convex, which is bounded in front by the FISSURE of ROLANDO, separating it from the frontal lobe; behind by the PARIETO-OCCIPITAL FISSURE, separating it from the occipital lobe; and below by the HORIZONTAL LIMB of the FISSURE of SYLVIUS, separating it from the temporo-sphenoidal lobe.

This surface is furrowed by two sulci, the one is directed downwards parallel to and behind the fissure of Rolando, and forms the posterior limit of the ASCENDING PARIETAL CONVOLUTION (post central); the other, the INTRA-PARIETAL SULCUS (fig. 47, intr. part.), arches from before backwards through the centre of the surface, and subdivides it into an upper division—the SUPERIOR PARIETAL LOBULE (fig. 47, s.p.l.); and a lower division—the INFERIOR PARIETAL LOBULE (fig. 47, i.p..l.). The inferior parietal lobule is again divisable into an ANTERIOR part arching round the posterior end of the horizontal limb of the fissure of Sylvius, and called the SUPRAMARGINAL GYRUS or CONVOLUTION of the PARIETAL EMINENCE (Turner); and a POSTERIOR part, behind the horizontal limb of the fissure of Sylvius, and round the hinder end of the PARALLEL SULCUS (fig. 49, parll. f.), and called the ANGULAR GYRUS (fig. 47, ang.). This later gyrus passes below, without any line of demarcation, into the middle temporo-sphenoidal convolution (fig. 47, m.t.s.). The angular gyrus probably contains the centre for sight, though the occipital lobes are closely connected with this same function.

The ascending frontal and ascending parietal convolutions contain the chief motor centres (fig. 50, page 84).

TABLE OF THE CONVOLUTIONS OF THE PARIETAL LOBE.

Parietal Lobe.	Outer surface.	Ascending parietal.	Supra marginal.
		Superior parietal.	
		Inferior parietal.	Angular.
	Inner surface.	See mesial surface of hemispheres.	

III. The **Occipital Lobe.**—This lobe presents a greater number of individual variations in the arrangement of its convolutions than any of the other lobes. Pyramidal in shape, with the apex backwards, it has three surfaces, an *external*, in contact with the parietal bone, an *internal*, forming part of the mesial surface of the hemisphere, and an *inferior*, continuous with the under surface of the temporo-sphenoidal lobe. At present we shall notice the external surface only; the others will be described with the corresponding surfaces of the hemispheres. The *external surface* is bounded in front by the PARIETO-OCCIPITAL FISSURE, and by a line drawn downwards from it across the surface (ii.) **The Nervous Constituents of the Grey Matter** are of two kinds:—(*a*) Multipolar nerve cells of large size, occurring either singly or collected into groups, (*vesicular columns*), the branching processes given off by the nerve cells, forming a fine but dense meshwork of fibrillæ. (*b*) Medullated nerve fibres, some of which are continuous with the axis-cylinder processes of the cells, whilst others are single fibres or strands of fibres, derived from various sources, and traversing the grey matter irregularly.

Vesicular Columns, or Groups of Nerve Cells in the grey matter of the cord (fig. 12, p. 18). The groups of nerve cells seen in transverse sections of the spinal cord are, you will readily understand, sections of columns of cells, which extend either through the whole length of the grey matter, or only through certain regions of it; hence they are known as vesicular or ganglionic columns.

The largest of these groups is that situated in the fore part of the anterior cornu. It can be traced throughout the entire length of the cord, and is known as the ANTERIOR VESICULAR COLUMN, though it can be subdivided into two groups—the one anterior or inner, the other lateral (fig. 12, p. 18, a.e.). In the lumbar region an additional posterior group, which lies behind the anterior, makes its appearance.

Since it is to these groups of cells of the anterior cornu that many of the anterior or motor nerve fibres can be traced, the entire collection has been termed the "motor vesicular column." More recently, however, it has been stated that the cells also exercise a trophic influence on the muscles. This conclusion receives support from the fact that, in any injury to the cells of the brain cortex (called the first trophic realm*), the degeneration of the muscles which follows is by no means rapid, whereas, if the cells of the anterior vesicular column (second trophic realm) be injured, besides paralysis of the nerves, rapid degeneration of the muscles is the result.

The second well-marked group of cells is placed at the base of the posterior horn, near its inner angle. It is found only along the middle region of the cord, from the seventh cervical to the first lumbar vertebra, and is variously known as POSTERIOR VESICULAR COLUMN, Clarke's column, Dorsal nucleus (fig. 12, p.c.). It has an intimate connection with the posterior or sensory nerve roots.

A third group of nerve cells, the NUCLEUS OF THE INTERMEDIO-LATERAL TRACT, (fig. 12, i.l.), lies at the root of the posterior cornu on its outer side, within the column of grey matter of the same name, and, like it, can be distinguished in the dorsal region only.

TABLE OF VESICULAR COLUMNS.

1. Anterior vesicular column.	Antero-internal group. Antero-external group.
2. Intermedio-lateral vesicular column.	
3. Posterior vesicular column ; Clark's column ; Dorsal nucleus.	

STRUCTURE.—The cells of the vesicular columns vary considerably both in size and shape. Most of

* These well-chosen terms we owe to Dr Wyllie, Lecturer on Medicine, School of Medicine, Edinburgh.

PLATE 3.

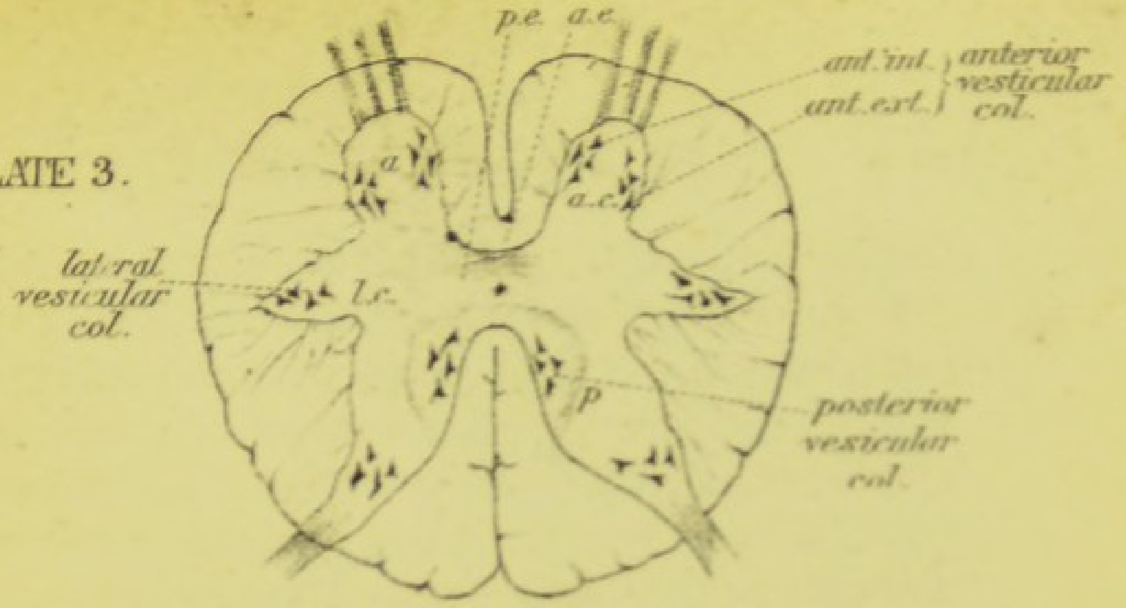

Fig. 12.

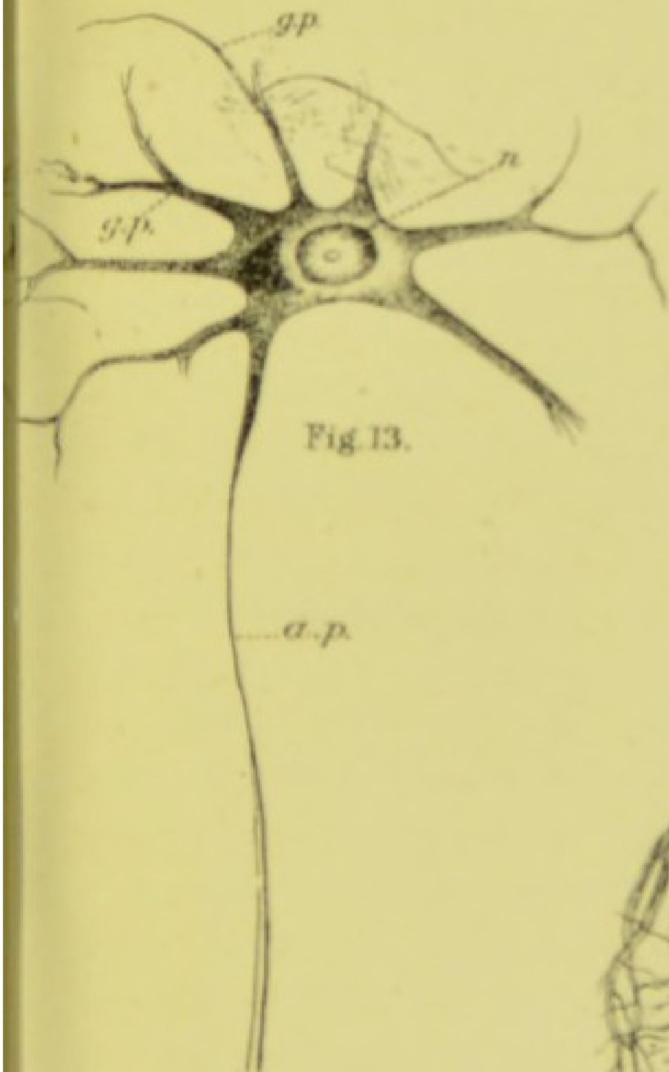

Fig. 13.

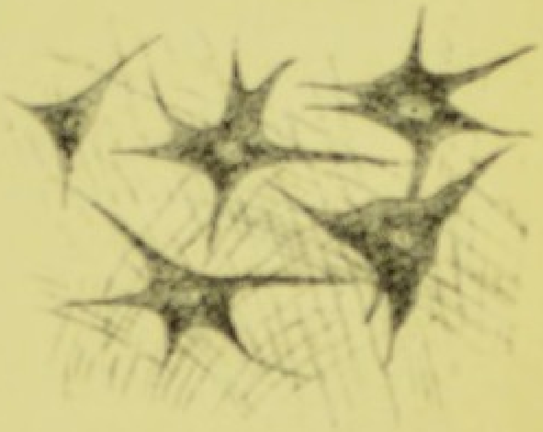

Fig. 14.

Fig. 15.

them are stellate or multipolar, (fig. 13 and 14, p. 18), but some give off only two processes, one or both of which soon divides into delicate branches, known as the grey processes. The cells themselves have no distinct nucleated sheath, and thus differ from those found in the various ganglia throughout the body. Each, however, has a large, round or oval nucleus, enclosed in a membrane, and containing a network of fibrillae and one or more nucleoli (fig. 14, p. 18).

The largest cells will be found in the anterior vesicular column, especially in its outer group (fig. 13); and similar ones occur in Clarke's column. In these situations the cells, besides their grey processes, are furnished with an unbranched process, which soon becomes encased in a medullary sheath. This is known as the axis-cylinder process.

In structure the medullated fibres in the grey matter are in all respects similar to those in the white columns, and will be subsequently described. (See page 23.)

II. The White Matter of the Spinal Cord.—Taking up the spinal cord, again examine it with the naked eye, and you will see that the white matter forms the outer or cortical part of the cord, and surrounds the grey centre. It is arranged in a series of columns, and gradually increases in amount from below upwards, being specially augmented in the cervical and lumbar enlargements. Compared with the grey matter, it is more abundant in the neck and back, but less so in the loins.

i. **White Columns or Segments of the Cord, and their Subdivisions** (fig. 19, p. 22).—Your attention, you will remember, has already been called to the fact that the exit and entrance of the nerve roots subdivide each lateral half of the cord into three longitudinal white segments or columns—namely, an ANTERIOR, a LATERAL, and a POSTERIOR; each of which, however, can be again subdivided into smaller tracts or strands, which have received special names (fig. 16, 17, 18, 19, p. 22).

To determine by actual dissection the course of the various tracts or strands of fibres which pass along these columns would be impossible. The task, however, has been much simplified by the study of development and of pathology; for "we may learn as much of the course of the fibres by studying them in their birth as in their death—in their development as in their decay." The former teaches us that different tracts or bundles of fibres acquire their white substance (medullary sheath) at different periods of their development, so that in specially prepared specimens we are enabled to pick them out and trace them through successive sections of the cord. On the other hand, the selective action exercised by disease, (so analogous to that exercised by certain poisons,) affords equally valuable information. For to Pathology we are indebted for the knowledge that, when a nerve fibre degenerates in consequence of lesion or disease, the proper nerve substance is replaced by connective tissue, which, when treated with certain staining re-agents, behaves differently from the surrounding undegenerated nerves. By the above means the following information, in regard to the columns of the cord, has been obtained:—

(*a*) **Anterior Column.**—In this column have been defined a median and a lateral division. The median division, ANTERO-INTERNAL TRACT (fig. 16, &c., a.i.), (the Direct pyramidal tract, Fasciculus of Türck*), is a well-marked bundle of fibres, situated close to the anterior median fissure. It is, as we shall see hereafter, a continuation of that part of the anterior pyramid of the medulla oblongata which does not decussate, hence its name—*direct* pyramidal tract.

The lateral part of the anterior column, ANTERO-EXTERNAL TRACT (fig. 16, &c., a.e.), forming by far the larger part, has also been called the Anterior root zone (Charcot), or Basis bundle (Turner).

(*b*) **Lateral Column.**—This well-defined tract, marked off on the surface of the cord by the antero-lateral and postero-lateral grooves, and limited internally by the two grey cornua, is composed of four distinct strands of fibres. Thus occupying the posterior part of the column, at a little distance from the surface

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* Referring to the use of men's names to denote anatomical facts, "I have avoided," says Gowers, "the use of these terms. This system of nomenclature is full of inconvenience, increasing the difficulties of the student, and leading to frequent mistakes in scientific writings. There are very few observations in medicine regarding which it is not obvious that they would speedily have been made by some one other than the actual observer; that it was very much of an accident that they were made by certain individuals. Scientific nomenclature should be itself scientific, not founded upon accidents. However anxious we may be to honour individuals, we have no right to do so at the expense of the convenience of all future generations of learners."

of the cord, is a bundle of fibres known as the CROSSED PYRAMIDAL TRACT (fig. 16, &c., c.p.), which, as we shall afterwards see, is continued upwards into the anterior pyramid of the *opposite* side of the medulla oblongata; hence the name *crossed* pyramidal tract.

The thin lamina of white matter, which separates this tract (crossed pyramidal) from the surface of the cord, constitutes the DIRECT LATERAL CEREBELLAR TRACT (figs. 16, &c., c.p., p. 22), so-called from its supposed connection with the cerebellum on the same side.

Then again Haddon and Gowers have been able to define two symmetrical areas, situated one in the anterior part of each lateral column in front of the crossed pyramidal tract (fig. 16, s.). These bundles are probably sensory in nature.*

The rest of the lateral column is called the MIXED ZONE (fig. 19, m.z.), though it is often divided into two parts, anterior and posterior mixed strands,—the latter being also called the "limiting layer" (fig. 19).

(*c*) **Posterior Column.**—The arrangement of the strands in this column somewhat resembles that in the anterior (fig. 19). Thus, especially in the cervical region, we find close to the posterior median fissure a narrow band called the POSTERO-INTERNAL TRACT (fig. 19, p.i.), (Posterior median column, Fasciculus of Goll); and an external division named the POSTERO-EXTERNAL TRACT, (Cuneate fasciculus, Posterior root zone, Fasciculus of Burdach) (fig. 19, p.e.). The distinction between these two parts of the posterior column is of considerable importance in the pathology of Locomotor Ataxy (Bristowe, p. 1019. Ed. 1884).

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* This tract is called by Gowers the antero-lateral ascending tract, (fig. 19, ant. lat. asc.)

PLATE 4.

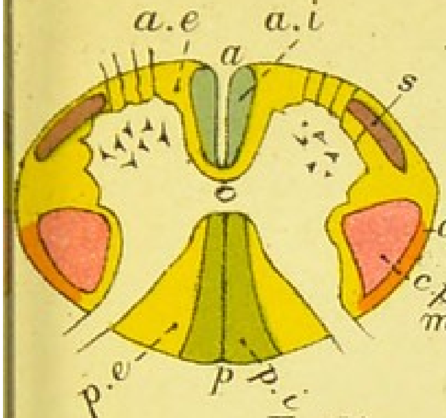


Fig.16.

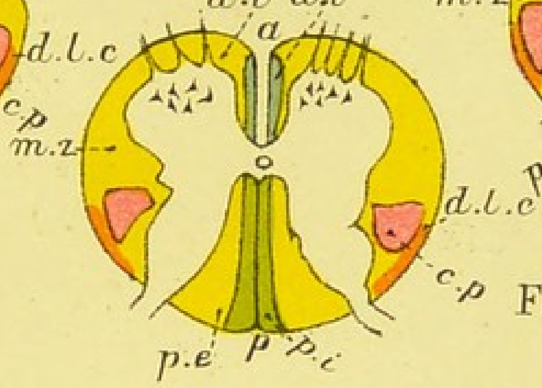


Fig.17

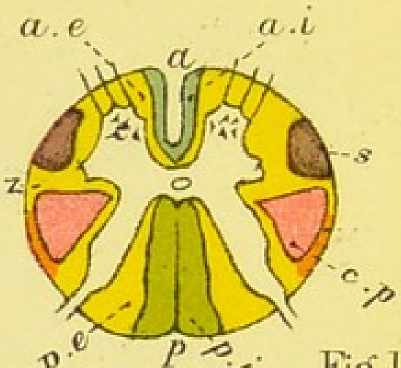


Fig.18.

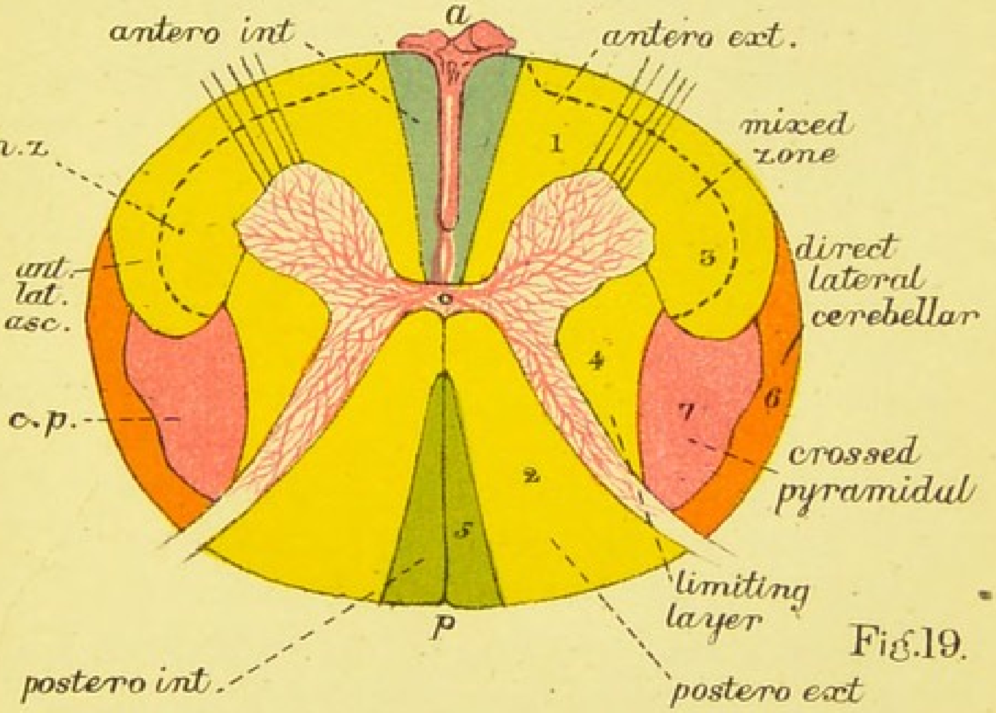


Fig.19.

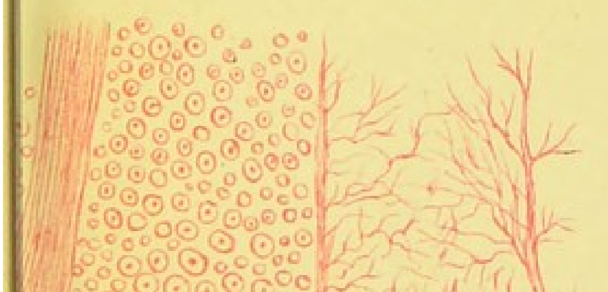


Fig.20.

Fig.21.

ii. **White Commissure.**—The two anterior white columns of opposite sides of the cord are united across the middle line by the anterior or white part of the spinal commissure (fig. 12, p. 18, a.c.). It is seen at the bottom of the anterior median fissure, and consists of decussating white fibres derived partly from the anterior column, partly from both anterior and posterior nerve roots.

TABLE OF WHITE TRACTS OF THE SPINAL CORD.

(Plate 4, fig. 19, p. 22.)

Anterior column.	1. *Antero-internal.* Fasciculus of Türck. Direct pyramidal. Uncrossed pyramidal. 2. *Antero-external.* Basis bundle (Turner). Anterior root zone (Charcot).
Lateral column.	1. *Crossed pyramidal.* 2. *Direct lateral cerebellar.* 3. *Sensory zone* (Gowers). 4. *Mixed zone*—anterior mixed; posterior mixed or limiting layer.
Posterior column.	1. *Postero-internal.* Fasciculus of Goll. 2. *Postero-external.* Fasciculus of Burdach. Posterior root zone (Charcot). Fasciculus cuneatus.

MINUTE STRUCTURE OF THE WHITE MATTER (fig. 20 and 21, p. 22).—With the exception of blood-vessels, and of the neuroglia which forms a supporting framework, the white substance of the cord is almost entirely made up of medullated nerve fibres, running for the most part longitudinally. Each fibre consists of a central core or axis cylinder which appears in section as a dark spot, surrounded by a laminated medullary sheath (fig. 20 and 21). Neither neurilemma nor nodes of Ranvier can be detected.

In addition to the accumulations of neuroglia already described under the names of substantia gelatinosa and central grey nucleus, there is upon the surface of the cord, immediately beneath the pia mater, a layer of this same substance, which sends processes into the various clefts and septa of the cord.

5. **Deep Origins of Spinal Nerves** (fig. 22).—The ANTERIOR NERVE ROOTS, taking their superficial origin from the antero-lateral groove, can be traced inwards through the peripheral white substance to the anterior cornu, which they enter in several bundles. Their fibres may be traced as follows (fig. 22, a.):—

1. To the lateral group of cells in the anterior horn.
2. To the lateral white columns.
3. To the posterior cornu.
4. To the anterior part of the commissure.
5. To the anterior group of cells in the anterior horn.

The POSTERIOR NERVE ROOTS enter the cord at the postero-lateral groove in two distinct bundles—external and internal (fig. 22, p.).

The fibres of the external bundle can be followed—

1. To nerve cells of posterior horn.
2. To anterior horn.
3. To posterior part of the commissure.

The fibres of the internal bundle do not pass straight to the grey matter, but enter the white substance of the posterior column, in which they run

PLATE 5.

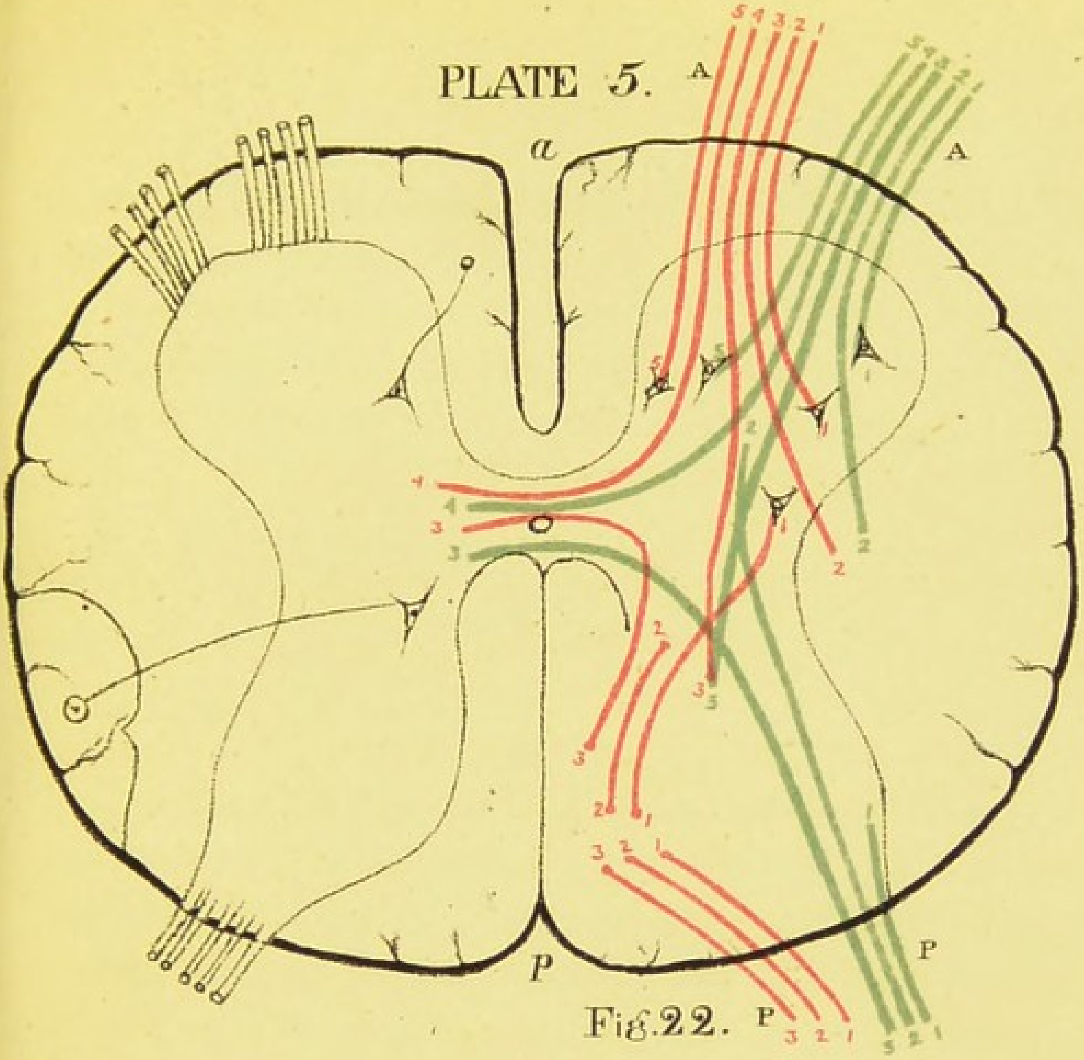


Fig. 22.

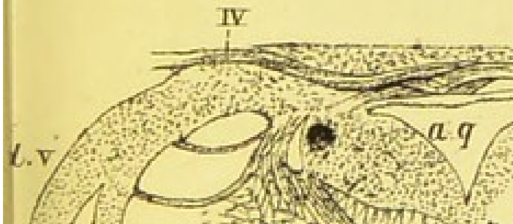


Fig. 23.

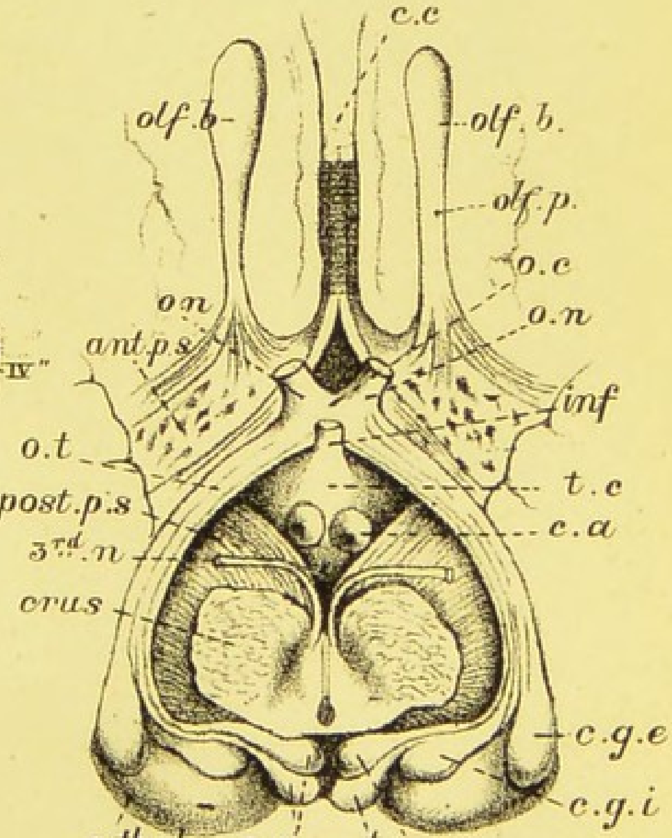


Fig. 24.

upwards for a variable distance, and ultimately pass to the following destinations :—

1. The lateral cells of the anterior horn.
2. The cells of Clarke's column.
3. The posterior part of the commissure.

SUMMARY.—To sum up, then, we have the cord presented to us as an elongated mass of nervous substance, consisting of white and grey matter; invested by three membranes; having two distinct enlargements; giving origin to thirty-one pairs of nerves; nourished by spinal vessels, and divided by anterior and posterior fissures into two lateral segments, each of which has three subdivisions.

We shall now pass to the description of the Brain and its Membranes.

CHAPTER II.

THE BRAIN
AND ITS
MEMBRANES.

UNDER the term BRAIN OR ENCEPHALON is included all that part of the great central nervous system which is enclosed within the cavity of the cranium. Invested by three membranes, it presents, as you will afterwards see, three distinct subdivisions: I. The CEREBRUM, a large convoluted mass; II. the CEREBELLUM or little Brain; III. the PONS VAROLII, a white transverse band; and IV. the MEDULLA OBLONGATA, the enlarged upper end of the spinal cord.

DISSECTION.—I. To expose the Membranes of the Brain.—Make an incision along the middle line through the entire thickness of the scalp, from the root of the nose in front to the external occipital protuberance behind. Turn back the pericranium to the level of the ears, and then saw through the outer table of the skull-cap along a line passing round the skull, about half an inch above the external occipital protuberance behind, and about the same distance above the supraorbital arch in front. Break through the inner table with the chisel and forcibly raise the detached skull-cap, which you will find more or less adherent to the subjacent membrane, especially along the lines of the cranial sutures. Branches of the meningeal arteries will be seen ramifying on the outer surface of the exposed membrane, between it and the bone.

II. To Remove the Brain.—With a sharp pair of scissors cut through the dura mater at the same level at which you have sawn the bones, and reflect it upwards towards the top of the head. Examine as far as you can the strong process, falx major, passing down mesially between the halves of the cerebral hemispheres. Divide this process in front where it is attached to the Crista Galli of the Ethmoid, and cut through the veins which enter the sinus contained within its upper border. Raising the falx out of the longitudinal fissure, turn it back, but do not cut it behind. Now pass the fingers of the left hand beneath the fore-part of the brain, and gently raise it from the anterior cranial fossae, taking care to detach the small, white, rounded bands, OLFACTORY LOBES (1st pair), from the cribriform plate of the ethmoid. (*a*) The OPTIC NERVES (2nd pair) and the (*b*) two INTERNAL CAROTIDS will now be seen close to the anterior clinoid processes, and should be divided. Piercing the dura mater, external to the carotid appears the round (*c*) 3RD NERVES, and in the free margin of the Tentorium Cerebelli, which is now exposed, will be seen the slender (*d*) 4TH NERVES. Cut through these, and through (*e*) the INFUNDIBULUM which will be seen passing down towards the Sella Turcica of the Sphenoid. Then with the point of the knife make an incision through the margin of the Tentorium on each side, just behind, and parallel to, the upper margin of the petrous part of the temporal bone, carrying the incision as far back as necessary, but being careful not to injure the parts beneath. You will now see the following nerves, which will require to be divided one after another. Just below the anterior end of the tentorium will be found (*f*) the large 5TH NERVES; nearer the middle line the slender (*g*) 6TH NERVES; below and external to the 5th, (*h*) the FACIAL AND AUDITORY parts of the 7th nerve and the auditory artery; immediately below the 7th (*i*) the THREE DIVISIONS of the 8TH NERVE; cut the glossopharyngeal and the vagus, but leave intact the spinal part of the spinal accessory; lower down near the middle line is the 9TH or HYPOGLOSSAL NERVE, consisting of two bundles which pass through two separate openings in the dura mater. Next pass the knife as far down the spinal canal as possible, and divide the spinal cord, the nerve roots attached to its sides, and the vertebral arteries as they wind round from the back. Tear through the veins of Galen, and the entire brain can now be easily removed from its bed, and should be at once placed in spirit. Leave it there for a few days; then examine and carefully remove the pia mater except at the back between the cerebrum and cerebellum.

Section I.

MEMBRANES OF THE BRAIN.

Cranial Dura Mater.—To examine the dura mater replace as far as you can the falx major and the tentorium cerebelli and fasten them in their places by a few stitches; but it will be far more satisfactory for you if you can obtain a specimen specially prepared to show the arrangement of the dura mater.

I. THE DURA MATER.

The **Cranial Dura Mater** is a dense white fibro-serous membrane, rough externally, smooth and polished within, where it is lined by a layer of endothelial cells similar to that which lines the spinal dura mater. Composed of two layers, an inner, which sends processes between the parts of the brain, and an outer, which forms the endosteum of the inner table of the cranium, it adheres to the bones of the skull, especially along the lines of the cranial sutures and at the base of the cranium. This latter fact accounts for the rare occurrence of accumulations of pus or blood in this situation. The dura mater also sends sheaths along the several cranial nerves as they leave the skull through their various foramina, and, passing into the orbital cavities, blends with their periosteum. At the lower margin of the foramen magnum it is closely attached to the bones, and becomes continuous with the spinal dura mater. Along certain lines, the two layers of which cranial dura mater is composed separate from each other, leaving variously shaped channels called VENOUS SINUSES, for the passage of the blood from the brain into the venous system.

Of the partitions given off from its inner layer, two, the FALX CEREBRI, and the FALX CEREBELLI, are vertical, the third, the TENTORIUM CEREBELLI, is usually said to be horizontal, though it is far more vertical than horizontal.

1. **Falx Cerebri**—So called from its sickle-shaped form, (fig. 25 and 26 f.m.,) is the vertical process of dura mater which is lodged in the great longitudinal fissure, and which separates the inner surfaces of the cerebral hemispheres from each other. In front it is pointed, and is attached to the apex and to the posterior margin of the Crista Galli. Behind it widens out and is fixed in the middle line to the upper surface of the Tentorium. Its upper convex margin contains the superior longitudinal sinus and adheres to the inner surface of the skull along the ridges on each side of the median depression. The lower margin concave and free, is in contact with the upper surface of the corpus callosum, and contains the inferior longitudinal sinus.

2. The **Falx Cerebelli** (fig. 25 and 26 f.c.) is the small median vertical triangular partition, attached behind to the internal occipital crest, and above, at its widest part, to the under surface of the tentorium cerebelli. Its free concave margin projects forwards and fits into the notch between the halves of the cerebellum, and its posterior attached margin contains the occipital simus, which is single above but bifid below.

3. The **Tentorium Cerebelli,** (fig. 25 and 26 t.c.,) supporting the posterior part of the cerebrum, passes forwards and upwards, somewhat horizontally, as an arched tent-like partition between the big brain and the little brain. Its posterior convex margin is attached behind to the transverse ridges on the occipital, parietal, and temporal bones, and to the upper margin of the petrous part of the temporal bones, and ends in front at the posterior clinoid processes. This margin contains the lateral sinuses behind and the superior petrosal sinuses in front. The anterior concave margin, free in the greater part of its extent, is attached on each side by a narrow slip to the anterior clinoid processes. Between this margin and the dorsum sellae of the sphenoid is an oval opening for the passage of the crura cerebri. Along the middle line of the upper surface of the tentorium runs the straight sinus, which receives the veins of Galen from the interior of the brain.

The MINUTE STRUCTURE of the dura mater of the brain is similar to that of the spinal cord.

TABLE.—Agreements and differences in the arrangement of the cranial and spinal dura mater:—

Agreements.
1. Both are fibro-serous membranes;
2. Both invest their respective organs;
3. Both form the boundaries of the subdural space.

Differences.
4. The cranial dura mater forms the periosteum to the bones, the spinal does not;
5. The cranial dura mater sends off processes between the parts of the brain; not so the spinal dura mater; it gives off no processes.
6. The cranial dura mater, by the separation of its constituent layers, encloses the various venous sinuses; the spinal dura mater forms no such sinuses.

The cranial dura mater receives its nerve supply from the 4th, 5th, and the sympathetic.

Pacchionian Bodies (or Glands) are small white elevations, which indent the inner surface of the skull, along each side of the middle line. They are overgrowths of the villi which normally exist in the arachnoid. Their use is unknown.

II. THE PIA MATER.

The **Pia Mater** of the brain, (fig. 27, p.), like that of the spinal cord, is an extremely fine, vascular, membrane, composed of a plexus of capillary blood-vessels held together by delicate, connective tissue. Covering the surface of the brain, it dips into the various fissures between the convolutions; and, from its inner surface, pass numberless blood-vessels for the nourishment of the substance of the brain. Besides the septa between the convolutions the pia mater also sends through the *great transverse fissure* (see Ventricles) into the lateral ventricles a special prolongation, the *velum interpositum* with its vascular fringe, the *choroid plexus;* and a similar vascular process of pia mater, known as the *tela choroidea inferior* or choroid plexus of the 4th ventricle, lies on the roof of that cavity.

In STRUCTURE the pia mater of the brain corresponds to the inner of the two layers of the pia mater of the cord. It receives its nerve supply from the 3rd, 5th, 6th facial, and 8th nerves, as well as from the sympathetic.

III. THE ARACHNOID.

The **Arachnoid** (fig. 27, a.) is a smooth, glistening, transparent, colourless membrane, situated between the dura mater and the pia mater. Formed of a single layer, which envelops the brain, but does not pass into its fissures, it is connected to the pia mater beneath by the subarachnoid trabeculæ, which are far more numerous than those in the spinal cord. At certain spots, especially at the base of the brain, the pia mater and the arachnoid are widely separated from each other, forming the SUBARACHNOID SPACES, which contains most of the cerebrospinal fluid.

There is no difference in STRUCTURE between the cranial and spinal arachnoid. The nerve supply to the former is probably the 5th, the facial, and the spinal accessory nerves.

Subarachnoid and Subdural Spaces (fig. 27, s.a.).—The space between the dura mater and the arachnoid is called the Subdural space, and is lined by endothelial cells. The space between the arachnoid and pia mater is the Subarachnoid space, and is crossed by the subarachnoid trabeculæ. Both its inner and outer walls are lined by endothelial cells, which also cover the surfaces of the trabeculæ. The Subarachnoid space is most distinct, I. at the great longitudinal fissure; II. at the base of the brain, in the triangular interval, between the anterior border of the Pons Varolii and the middle and anterior lobes of the cerebrum; III. posteriorly, between the cerebellum and the medulla oblongata.

Cerebrospinal Fluid.—The meshes of the subarachnoid trabeculæ are occupied by the cerebrospinal fluid, which communicates with the fluid in the spinal subarachnoid space, through the *foramen of Majendie* in the roof of the 4th Ventricle, (fig. 35, p. 54), and through two similar openings in the ventricular roof between the medulla and cerebellum, behind the upper roots of the glossopharyngeal nerves. The cerebrospinal fluid is not merely intended to fill the subarachnoid space, but helps to protect the nerve centres from sudden shocks; acting in fact as a water-bed (Hilton) on which the brain rests. According to Foster it is probable that the cerebrospinal fluid, being of the nature of lymph, subserves the nutrition of the brain.

IV. VENOUS SINUSES.

The sinuses of the brain, formed by the separation of the two layers of the dura mater, are lined by endothelial cells continuous with those in the interior of the veins. They are fifteen in number, five paired and five single. The single sinuses are the superior and the inferior longitudinal; the straight sinus; the circular, and the transverse. The paired set includes the two superior and the two inferior petrosals, the two cavernous and the two occipital sinuses.

1. The **Superior Longitudinal Sinus** (fig. 25 and 26, p. 34) begins in front at the foramen cæcum as a small vein, and thence arches upwards and backwards in the convex margin of the falx cerebri to reach the internal occipital protuberance, where it is joined by several other sinuses at the triangular dilation, called the Torcular Herophili or the meeting of the sinuses. Cut open the sinus in its entire length and you will see that it is wider above than below, being triangular in section, and that it increases in size as it passes backwards, its cavity being crossed by many slender bands—Chordæ Willisii. Numerous veins, from the substance of the brain, pour their blood into this sinus. They run mostly from before, backwards, piercing the wall of the sinus by slit-like openings, which act as valves and thus prevent regurgitation of the blood. Other smaller veins enter it from the diploë of the surrounding bones, and it receives an emissary vein through the parietal foramen.

2. The **Inferior Longitudinal Sinus** (fig. 25 and 26) is really a small vein contained in the free concave border of the falx major. It commences in front by small venous radicles within the substance of the falx and ends behind in the straight sinus.

3. The **Lateral Sinuses** (fig. 25 and 26).—These

PLATE 6.

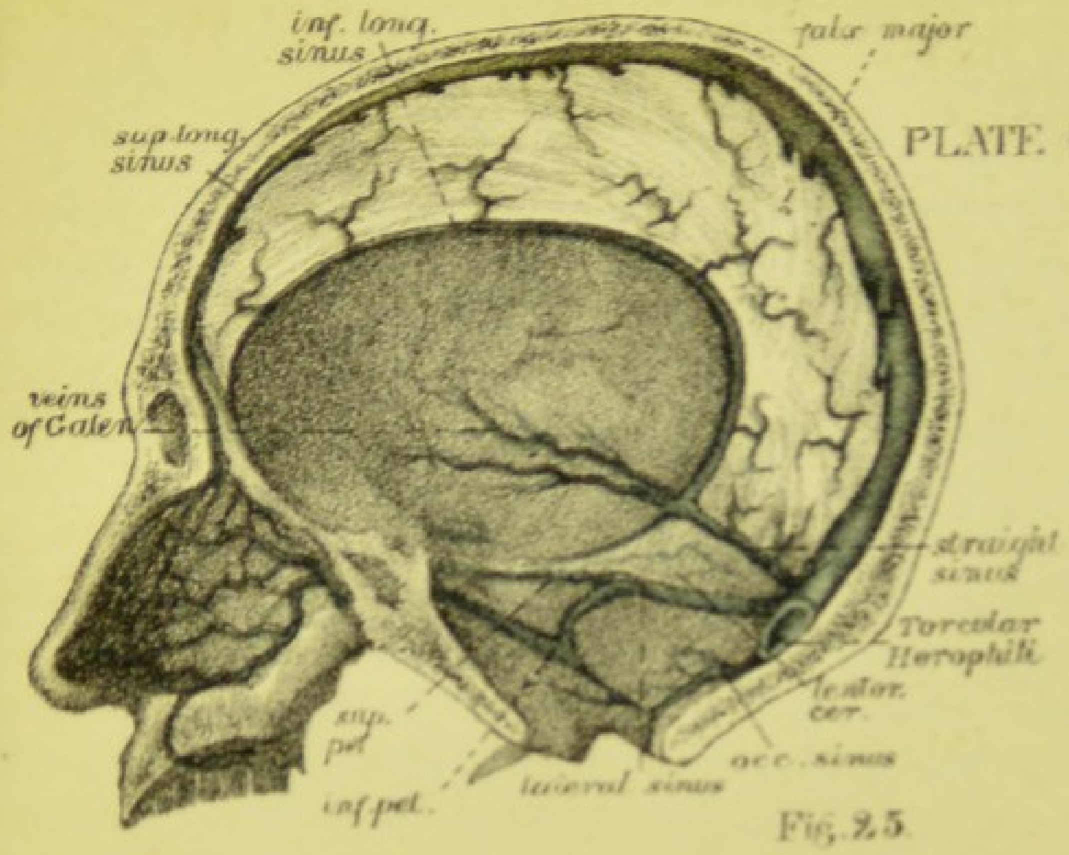


Fig. 25.

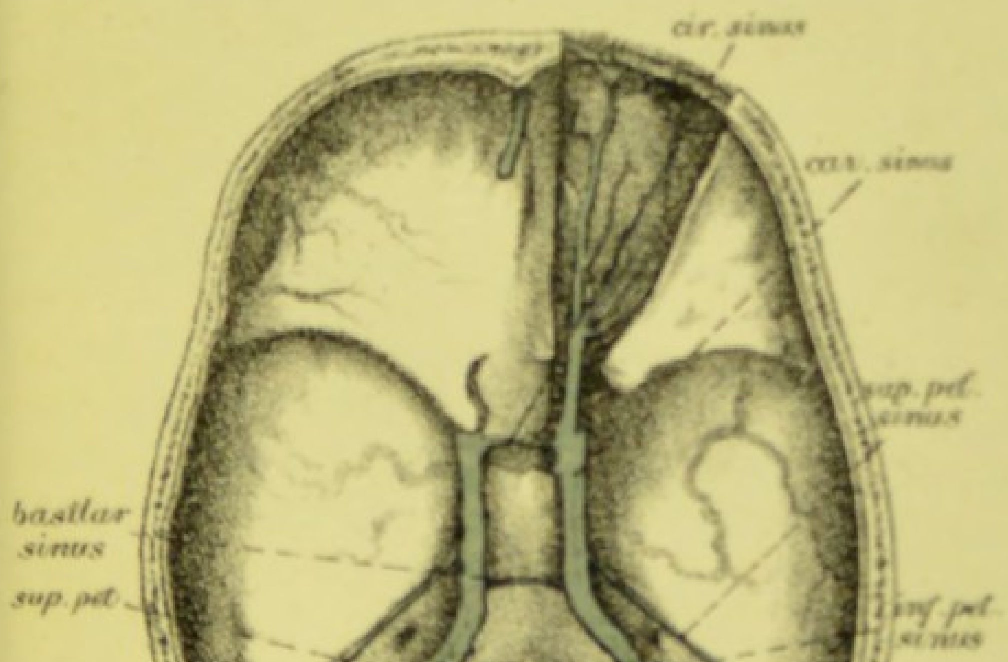


Fig. 26.

are two in number, right and left, the right being usually the larger of the two. Through them all the venous blood from the brain reaches the internal jugular veins. They commence at the internal occipital protuberance, and running outwards and downwards in the attached margin of the tentorium cerebelli in the grooves in the occipital, parietal, and temporal bones, finally turn forwards to end in the bulb of the internal jugular vein. Blood enters these sinuses from the superior and inferior petrosals, from the inferior cerebral and cerebellar veins, from the diploë of the bones, and from the scalp by emissary veins.

4. The **Straight Sinus** (fig. 25 and 26) lies in the middle line of the upper surface of the tentorium where the falx major is attached. Behind, it ends at the meeting of the sinuses, while in front it receives the inferior longitudinal sinus and the two veins of Galen, the latter bringing blood from the third and from the lateral ventricles. Cerebral and cerebellar veins also open into it.

5. **The Cavernous Sinuses,** (fig. 25 and 26), so called from the spongy appearance of their interior, are placed in the grooves on each side of the body of the sphenoid. They are oval in section, and contain in their thickened outer wall the 3rd, the 4th, and the ophthalmic division of the 5th nerve, while internally, and separated from the blood of the sinus by a thin lining membrane, is the internal carotid artery, with the 6th nerve on its outer side. These sinuses communicate with the circular sinus, with the superior

and inferior petrosals, and receive small cerebral veins, and the veins from the orbit (fig. 26).

6. The **Circular Sinus** (fig. 25 and 26) surrounds the Pituitary Body in the Sella Turcica. At each side it communicates with the cavernous sinuses.

7. **Petrosal Sinuses** (fig. 25 and 26) are two on each side; the superior and the inferior. The **superior petrosal** sinus lies along the upper border of the petrous part of the temporal bone, and connects the cavernous sinus with the lateral sinus. The **inferior petrosal** sinus runs in the groove between the occipital bone and the petrous part of the temporal bone. It unites the cavernous sinus to the lateral before it enters the jugular vein. Cerebral, cerebellar, tympanic, and auditory veins pour their blood into one or other of these sinuses.

8. The **Transverse Sinus**, (fig. 25 and 26), sometimes double, is placed across the basilar process of the occipital bone, connecting together the inferior petrosal sinuses. It communicates below with the anterior spinal veins.

9. The **Occipital Sinuses** (fig. 25 and 26) commence below, near the foramen magnum, as two small channels which run upwards in the attached margin of the falx cerebelli, and then join above to form a single sinus which opens into the Torcular Herophili.

Emissary Veins are small vessels which pass through foramina in the skull, and unite the veins of the scalp with the cranial sinuses. If it were not for these veins, injuries to the scalp would lose half their significance (Treves).

The **Meningeal Arteries**, which supply the dura mater with blood, ramify in branching grooves on the inner surface of the cranium between it and the outer surface of the dura mater. From the fossæ in which they ramify they are called the anterior, the middle and the posterior meningeal arteries.

Section II.

ARTERIES OF THE BRAIN.

(Plate 7, fig. 28, p. 38.)

Take the brain out of spirit and examine the arrangement of its arteries.

The arteries of the brain are derived from the *two internal carotids* and from the *two vertebrals*.

I. The **Internal Carotid Arteries**, when they reach the anterior clinoid processes, give off the ophthalmic branches, and then divide into anterior, and middle cerebral, and posterior communicating.

1. The **Anterior Cerebral Arteries** run forwards to the fore part of the great longitudinal fissure, and, curving round the anterior end of the corpus callosum, pass backwards on its upper surface under the name of the arteries of the corpus callosum. At their commencement they are joined by a short transverse branch — the *anterior communicating*—while behind they anastomose with the posterior cerebral arteries. They supply blood to the frontal and olfactory lobes, to the optic nerves, to the corpus callosum, and to the anterior perforated spots.

2. **Middle Cerebral or Sylvian Arteries** are the largest branches of the internal carotid, and pass upwards and outwards in the fissure of Sylvius till they reach the surface of the island of Reil, where they ramify in the pia mater, forming part of the cortical system of arteries: they anastomose freely with the anterior and posterior cerebral arteries. Other branches, furnished through the anterior perforated spot to the corpus striatum, are all terminal arteries and belong to the "ganglionic system" of branches. They are (1) the lenticular; (2) the lenticulo-striate; (3) the lenticulo-optic, and will be again referred to in describing the nuclei of the ventricles of the hemispheres. The middle cerebral artery is the one chiefly concerned in cerebral hæmorrhage.

3. **Anterior Choroidal Arteries,** one or two in number, are either branches of the internal carotids or of the middle cerebrals. Entering the fissure between the temporo-sphenoidal lobe and the crus cerebri (fig. 28), they reach the descending cornu of the lateral ventricle and there form the vascular fringe—the choroid plexus.

4. **Posterior Communicating Arteries** run backwards and join the posterior cerebral arteries (branches of the basilar artery), and thus is established a free anastomosis between the carotids and the vertebrals.

II. The **Vertebral Arteries**—branches of the subclavian—enter the foramen magnum by perforating the dura mater, and then curve round to the anterior surface of the medulla. At the lower border of the

PLATE 7.

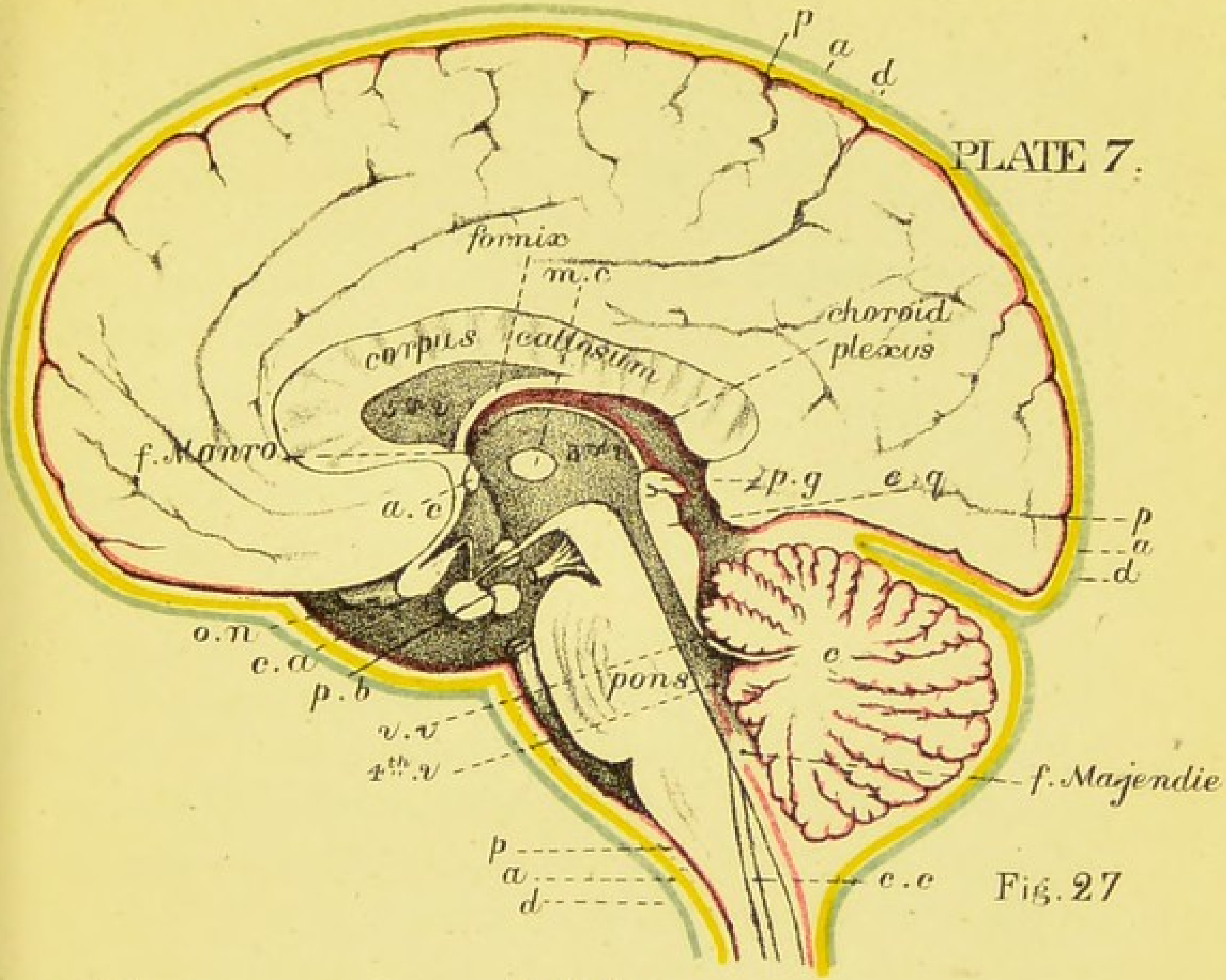


Fig. 27

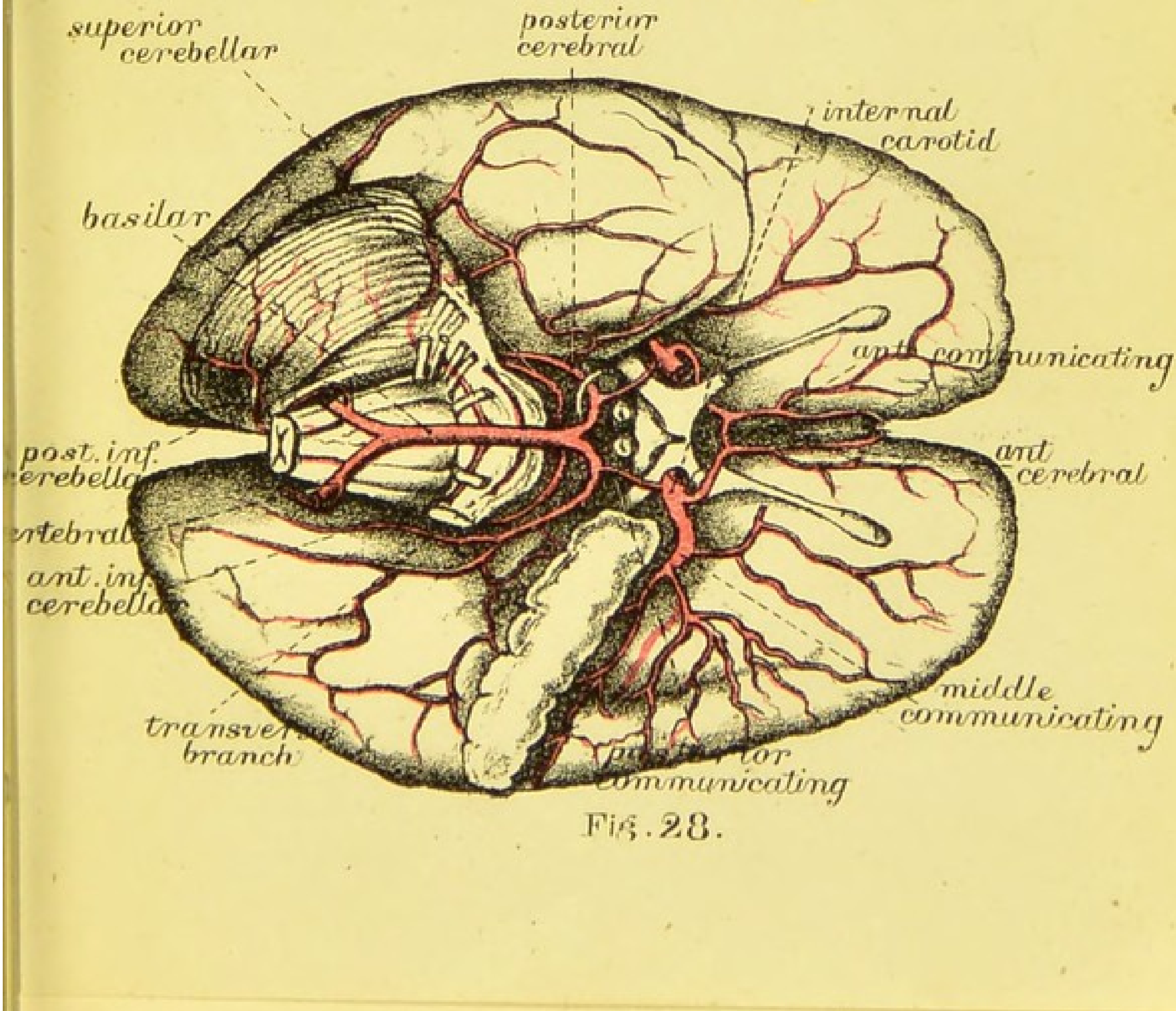


Fig. 28.

2. **Middle Cerebral or Sylvian Arteries** are the largest branches of the internal carotid, and pass upwards and outwards in the fissure of Sylvius till they reach the surface of the island of Reil, where they ramify in the pia mater, forming part of the cortical system of arteries: they anastomose freely with the anterior and posterior cerebral arteries. Other branches, furnished through the anterior perforated spot to the corpus striatum, are all terminal arteries and belong to the "ganglionic system" of branches. They are (1) the lenticular; (2) the lenticulo-striate; (3) the lenticulo-optic, and will be again referred to in describing the nuclei of the ventricles of the hemispheres. The middle cerebral artery is the one chiefly concerned in cerebral hæmorrhage.

3. **Anterior Choroidal Arteries,** one or two in number, are either branches of the internal carotids or of the middle cerebrals. Entering the fissure between the temporo-sphenoidal lobe and the crus cerebri (fig. 28), they reach the descending cornu of the lateral ventricle and there form the vascular fringe—the choroid plexus.

4. **Posterior Communicating Arteries** run backwards and join the posterior cerebral arteries (branches of the basilar artery), and thus is established a free anastomosis between the carotids and the vertebrals.

II. The **Vertebral Arteries**—branches of the subclavian—enter the foramen magnum by perforating the dura mater, and then curve round to the anterior surface of the medulla. At the lower border of the

PLATE 7.

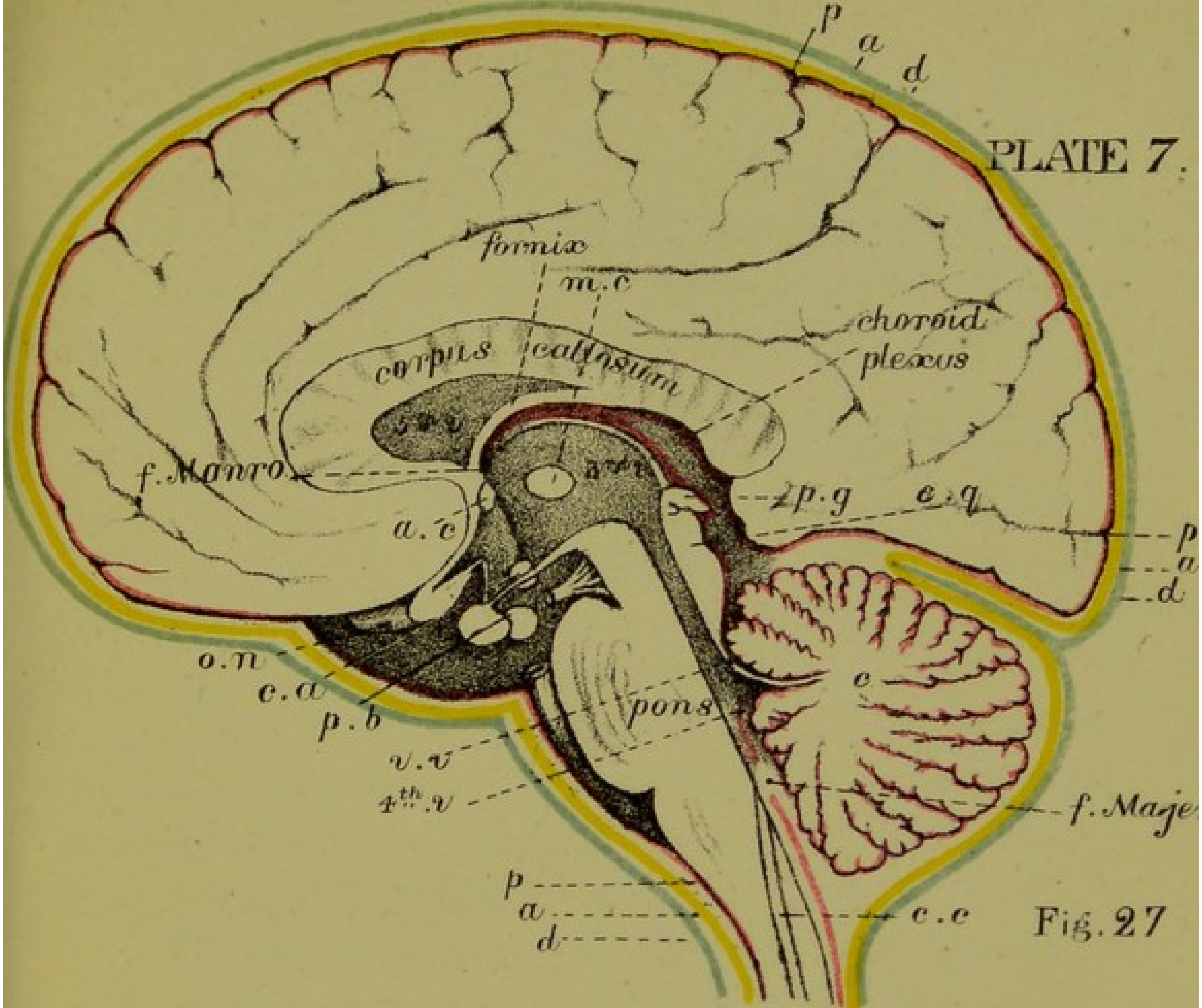
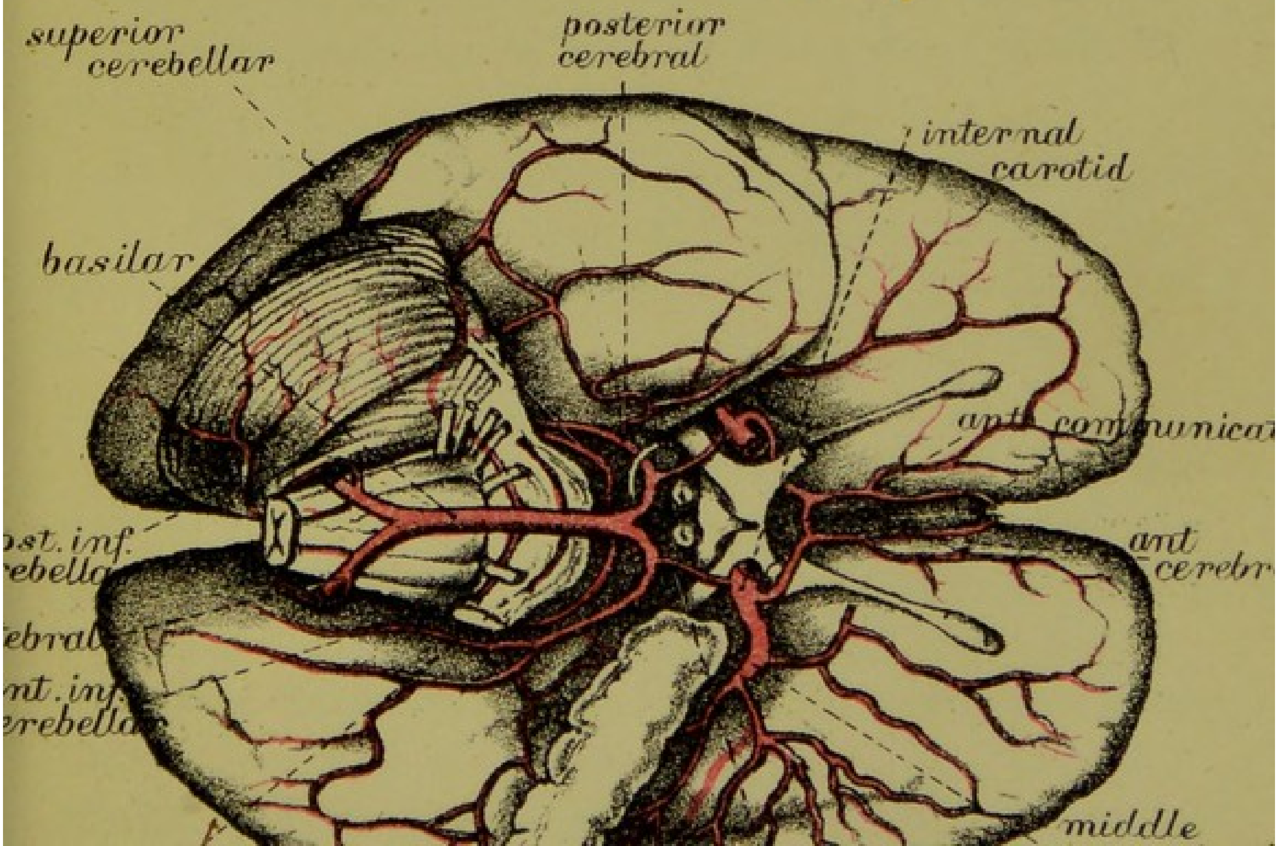


Fig. 27



pons they unite to form a single trunk—the Basilar Artery—which may be seen running in the groove on the front of the Pons till it reaches the upper margin, when it divides into two branches—the POSTERIOR CEREBRAL ARTERIES.

1. **Branches of the Vertebral Arteries.**—Only one branch, *the posterior inferior cerebellar*, which, however, is sometimes a branch of the basilar, is given off by the vertebral artery to the brain. It supplies the under surface of the cerebellum.

2. **Branches of the Basilar.**—*(a.) Transverse branches*, three or four in number, run transversely outwards on the Pons. One of them, the internal auditory branch, passes into the internal auditory meatus.

(b.) Anterior inferior cerebellar arteries, which pass to the anterior part of the lower surface of the cerebellum, and anastomose with the other cerebellar arteries.

(c.) Superior cerebellar arteries, given off near the termination of the basilar, supply the upper surface of the cerebellum, and send branches to the valve of Vieussens, to the pineal gland, and to the velum interpositum.

(d.) The posterior cerebral arteries—the terminal branches of the basilar curve outwards and backwards, round the crura cerebri, to the under surface of the posterior cerebral lobes, supplying them and anastomosing with the anterior and the middle cerebral arteries. They give branches to the posterior perforated spot and to the velum interpositum (posterior choroidal).

Circle of Willis (fig. 28, p. 38).—This important arterial inosculation takes place at the base of the brain between the internal carotids and the vertebrals. In front the circle is formed by the anterior communicating, which joins together the two anterior cerebral arteries; behind by the two posterior cerebral arteries, branches of the basilar; and on each side by the internal carotids, the anterior cerebrals, and the posterior communicating.

In front
ANTERIOR COMMUNICATING.

On each side

ANTERIOR CEREBRAL.	ANTERIOR CEREBRAL.
INTERNAL CAROTID.	INTERNAL CAROTID.
POSTERIOR COMMUNICATING.	POSTERIOR COMMUNICATING.

Behind the
TWO POSTERIOR CEREBRALS,
Branches of the
BASILAR.

Special Characters of the Cerebral Circulation are—

(1.) The free anastomosis at the circle of Willis, which provides a ready supply of blood from other vessels in case of the sudden blocking of any of the more direct channels.

(2.) The tortuous course through bony canals of the arteries as they enter the skull, thus mitigating the force of the heart's beat.

(3.) Their ramifications in the pia mater before entering the substance of the brain.

(4.) The thinness of the arterial walls, and the smallness of the capillaries.

(5.) The existence of venous sinuses which are without valves, and which do not run with the arteries; the larger arteries, in fact, having no companion veins.

Section III.

SUBDIVISIONS OF THE BRAIN.

General Outline of the Brain.—Placing the brain before you, you will see that it is an oval-shaped mass of nervous substance that has not inaptly been likened to the kernel of a walnut. "In a very special and particular sense," says Wilks, "one cannot but be forcibly struck with the resemblance between the human head and a walnut. There is first the pericranium and the skin, then the bone and the shell; within a dura mater and a thick membrane lining the shell of the fruit, then the pia mater and the delicate membrane covering the kernel, which is again made up of convolutions into two masses joined together by a commissure or corpus callosum."

The *upper* surface of the brain is arched and convex, and presents many tortuous folds or convolutions of nerve substance with intervening furrows, the whole giving to the exterior of the brain a most characteristic appearance. Along the middle line this aspect of the brain is divided into two similar halves by a deep longitudinal fissure, which lodges the falx cerebri. These two symmetrical halves are the CEREBRAL HEMISPHERES, and they together form the first great division of the encephalon—the

CEREBRUM. On separating the walls of this median cleft you will find that, in front and behind, it extends right through to the base of the brain; but that in the middle of its extent, it is interrupted below by a transverse band of nerve fibres, the *corpus callosum* or great commissure of the brain.

The *under* surface of the brain, convoluted similarly to the upper surface, is very irregular, for it fits into the corresponding fossæ at the base of the skull. It is on this aspect that you will recognise the three other subdivisions of the brain—viz., (1) the CEREBELLUM, (fig. 48, c.) or little brain, lying behind and below the posterior part of the cerebral hemispheres; (2) the PONS VAROLII, (fig. 48, p.) a broad white band, crossing transversely between the two halves of the cerebellum and in front of the upper part of the medulla; (3) the MEDULLA OBLONGATA, (fig. 48, m.) or bulb, placed between the cerebrum above, the pons in front and the cerebellum behind, and serving to connect these several parts of the brain with the spinal marrow. We shall describe (1) the MEDULLA; (2) the PONS; (3) the CEREBELLUM; (4) CEREBRUM.

I.—MEDULLA OBLONGATA.

The **Medulla Oblongata**, the most complicated portion of the central nervous system, is, as you already know, the expanded upper end of the spinal cord, and, like it, is composed of grey and white matter. By its anterior surface it rests upon the basilar process of the occipital bone, and in general outline is more or less conical, with its long axis nearly vertical, its base being directed upwards and forwards towards the pons, its apex downwards and backwards, and continuous with the spinal marrow at the lower border of the foramen magnum. In length it measures about 1¼ inches; in breadth at its widest part about 1 inch; in thickness about ½ an inch. On its anterior aspect it is convex, and is limited, above, by the transverse fibres of the pons; below, by what is known as the decussation of the pyramids—several bands of fibres passing from one side of the medulla to the other. Behind, on the other hand, it is convex in its lower half, but above it expands and becomes flattened to form the rhomboidal depression called the floor of the 4th ventricle. On this aspect its upper boundary is marked by several transverse lines—the striæ acusticæ—running across the widest part of the ventricular floor (fig. 30); the lower boundary is purely artificial, corresponding with the lower margin of the foramen magnum. On its lateral aspect the medulla supports an oval eminence—the olivary body, crossing which you may be able to make out several transverse lines, the external arciform fibres (fig. 29 and 33, a.f.), the significance of which you will understand hereafter.

1. Fissures of the Medulla.

(Fig. 29 and 30.)

Like the spinal cord the medulla is a symmetrical organ, being divided by superficial median clefts (anterior and posterior) into two similar lateral segments, which are again subdivided by the continuation upwards, though not in a direct line, of the place of origin of the anterior and posterior spinal nerve roots.

1. The ANTERIOR MEDIAN FISSURE ends above, at the lower margin of the pons, in a slight recess needlessly named the foramen cœcum; while below, at the lower limit of the medulla, it is interrupted by the decussation of the pyramids.

2. The POSTERIOR MEDIAN FISSURE expands above into the floor of the 4th ventricle, along the centre of which runs a mesial groove in a line with the median fissure of the cord.

3. The LATERAL FISSURES give origin to the roots of the 8th and 9th pairs of cranial nerves; the 8th pair springing from the continuation of the postero-lateral groove, and the 9th pair from that of the antero-lateral groove. By means of these several fissures the surface of each half of the medulla is marked out into three areas, for the most part artificial,—viz., an anterior, between the anterior median fissure and the line of origin of the 9th nerve; a lateral, between the 9th nerve in front and the 8th nerve behind; and a posterior, between the posterior median fissure and the 8th pair of nerve roots.

2. AREAS OR WHITE COLUMNS OF THE MEDULLA.

(Fig. 30 and 31, p. 44.)

It will be convenient to begin with the description of the posterior area.

I. The **Posterior Area.**—The *upper* portion of this area enters into the formation of the floor of the 4th ventricle. This cavity should naturally be described at this stage, but since many of its parts are connected with the pons and cerebellum, we are forced

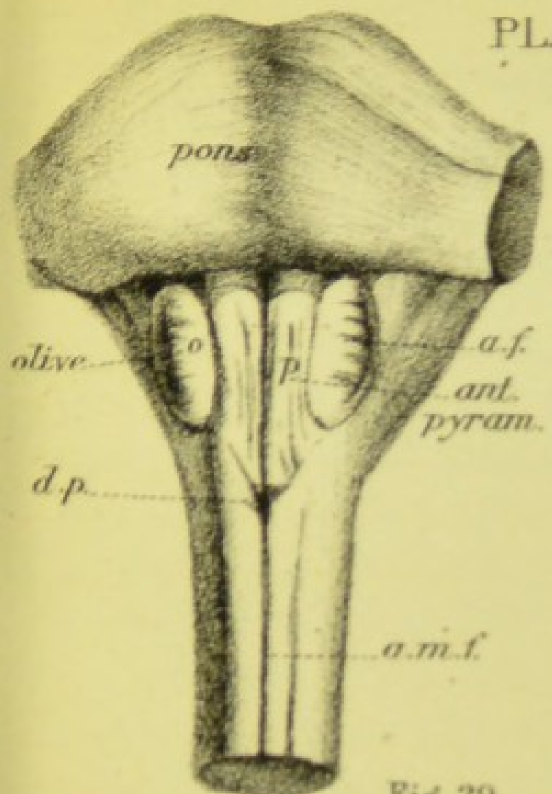


Fig. 29.

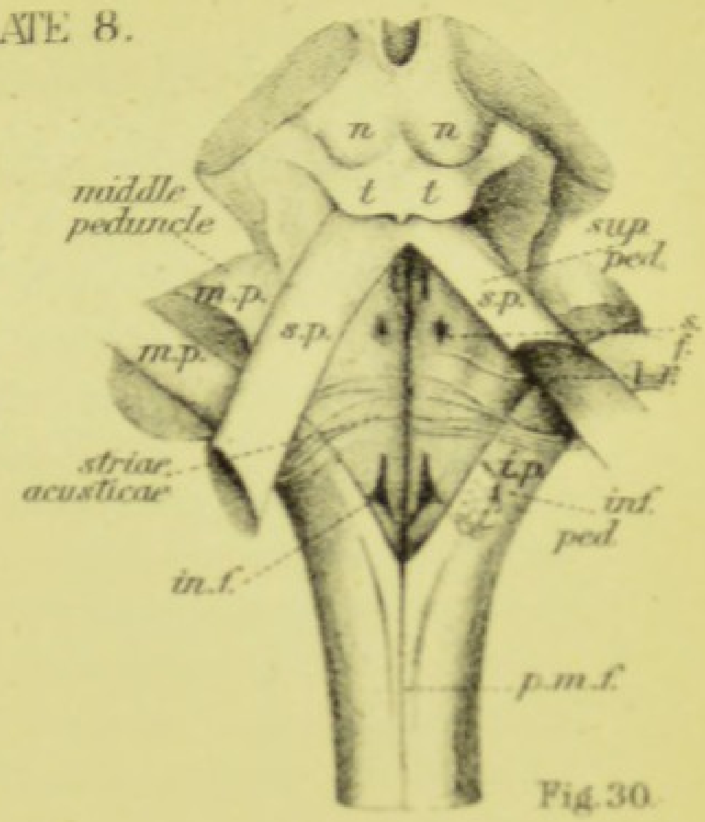


Fig. 30.

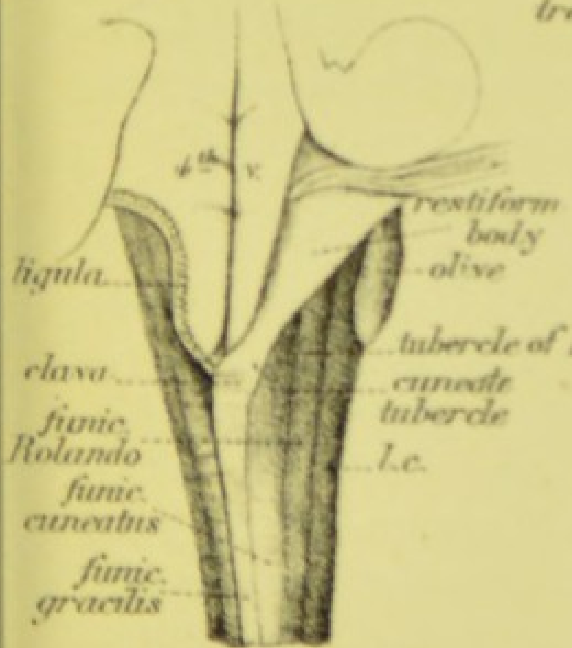


Fig. 31.

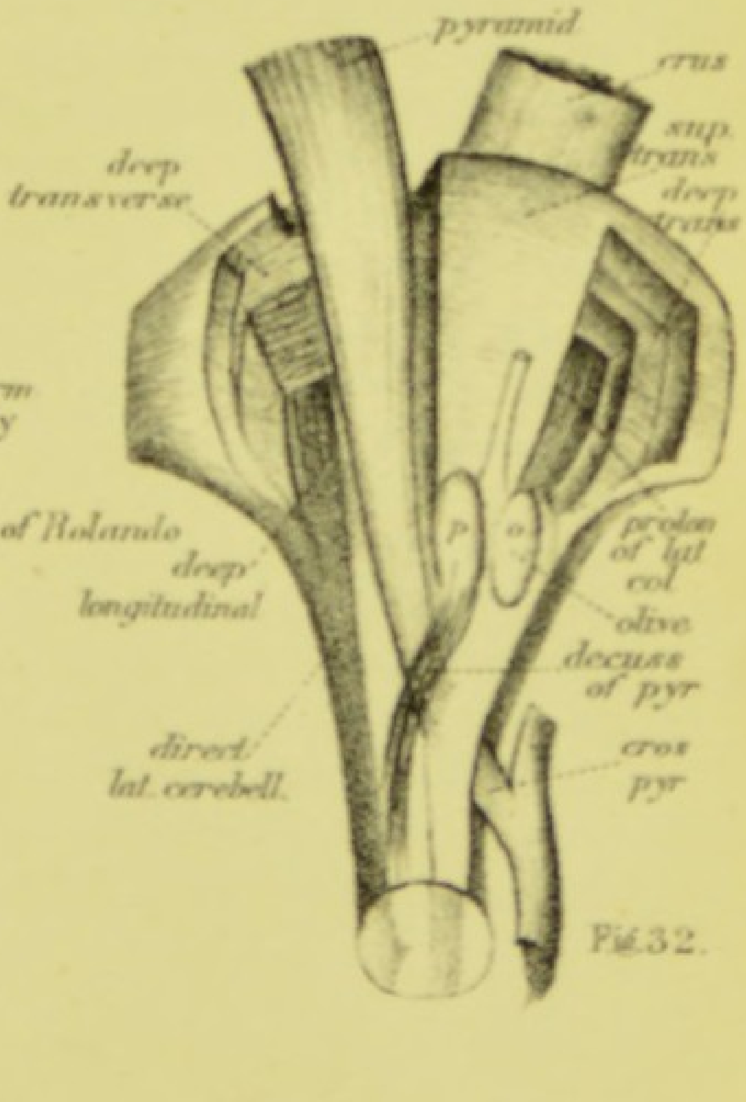


Fig. 32.

to defer the account of it until we have treated of those divisions of the brain.

The *lower* portion of the posterior area is, for the most part formed by the upward prolongation of the various white tracts of the posterior column of the cord—the several strands there defined, changing, when they reach the medulla,—their arrangement, their position, and their names. There are, however, on this aspect of the medulla, two tracts,—the FUNICULUS OF ROLANDO, AND THE RESTIFORM BODY—not represented in the posterior column of the spinal cord.

In dealing with the white substance of that column, you will doubtless remember, that we called your attention to the existence, in the cervical region, of a strand, close to the posterior median fissure, called the *postero-internal strand* (fasciculus of Goll). Now, traced into the medulla, this strand becomes more prominent, and at the point where the central canal of the cord becomes the cavity of the 4th ventricle, this fasciculus enlarges, and is removed a little to one side. As we follow it upwards, it tapers to a point and becomes gradually lost (fig. 31 and 33), though we shall afterwards be able to trace it, along with the next fasciculus, to the cerebrum. It is called the FASCICULUS GRACILIS (slender), (fig. 31, f.g.), and its enlarged upper end is known as the CLAVA (a club), (fig. 31, c.)

The outer division of the posterior column of the spinal cord, the *postero-external strand*, (fasciculus of Burdach, or cuneate fasciculus), passes into the medulla under this latter name; and expanding above into a tubercle, the CUNEATE TUBERCLE (fig. 31, c.t.), reaches upwards beyond the clava, and forms one of the lateral boundaries of the lower parts of the 4th ventricle (fig. 31).

The next tract—the FUNICULUS OF ROLANDO (fig. 31, f.r.) is not represented in the white matter of the spinal cord. Of a greyish colour (for there is little or no white matter on its surface), it lies outside the funiculus cuneatus, between it and the line of origin of the roots of the 8th pair of nerves. Like the two tracts previously mentioned, it expands above into a tubercle, the TUBERCLE OF ROLANDO (fig. 31. t.r.).

The remaining prominence, the largest and most con spicuous on this surface of the medulla, is the INFERIOR CEREBELLAR PEDUNCLE or Restiform Body (*restis*, a rope), (fig. 31, r.b.). Placed behind, and to the outer side of the lateral column of the cord, it lies above the clava, the cuneate tubercle, and the tubercle of Rolando, and when looked at from the surface seems to be incorporated with these fasciculi, though not so in reality, for, as we shall afterwards see, it is composed of fibres, derived, for the most part, from the lateral column of the spinal cord.

II. The **Lateral Area** of the Medulla, continuous with the lateral column of the cord, lies between the roots of the hypoglossal nerve in front and those of the 8th nerve behind. It is wider below than above, where it is partially hidden from view by the oval eminence—the Olivary Body. To determine the origin of its various strands we must refer back to the constitution of the corresponding column of the spinal cord. You will recollect that, in that column, we traced three tracts—the *direct lateral cerebellar*, the *crossed pyramidal*, and the *mixed zone*. The crossed pyramidal tract can be followed to the anterior pyramid of the opposite side of the medulla. The direct lateral cerebellar tract, on passing up into the medulla, will be seen as a superficial band of fibres (fig. 33. p. 48), running upwards and backwards across the line of origin of the 8th pair of nerve roots over the funiculus of Rolando, above its tubercle and across the cuneate funiculus. Then turning sharply upwards, it is joined by a set of fibres—the EXTERNAL ARCIFORM FIBRES (fig. 33), which, together with it, form the RESTIFORM BODY OR INFERIOR PEDUNCLE OF THE CEREBELLUM (fig. 33, r.b.).

NOTE.—According to the view here taken, the Restiform Body is made up of fibres derived from two sources—(1) the direct lateral cerebellar tract, from the lateral column of the cord and (2) the arciform fibres; the several tracts of the posterior area of the Medulla taking no part in its formation as was formerly supposed.

Another view, however, includes, under the term Restiform Body, not only the arciform fibres and the cerebellar tract, but the whole of the posterior area of the Medulla, except the fasciculus gracilis, which is then called the posterior pyramid; while a third view includes under this term the whole posterior area of the Medulla.

The remainder of the lateral column—the *mixed zone*—when traced upwards is seen to dip under the olivary body, so that only a small part of it is visible on the surface of the medulla, as a narrow white strand (tract of the fillet) between the olivary body and the roots of the 8th pair of nerves. Most of the fibres of this strand go to form part of a network of fibres that will become familiar to us under the name FORMATIO RETICULARIS. Thus, then, the fibres of the lateral column of the spinal cord, on reaching the medulla, are disposed of in three ways (see fig. 33): I. Some—crossed pyramidal tract—go to the opposite anterior pyramid; II. others—direct lateral cerebellar tract—to the Restiform Body, and thence to the cerebellum; III. others—the mixed zone—pass partly behind the olive and join the tract of the olivary fillet, and partly beneath the olive to the formatio reticularis.

Olivary Body—Olivary Fillet. The Olivary Body—the oval prominence, about ½ an inch long, placed at the upper end of the lateral area of the medulla, is bounded in front by the roots of the 9th nerve, but is separated behind from those of the 8th nerve by a narrow white tract—the tract of the fillet (lemniscus, olivary fasciculus), which, as we have already seen, is part of the mixed zone of the lateral column of the cord.

III. The **Anterior Area** of the medulla lies between the anterior median fissure, and the roots of the hypoglossal nerve, which serve to separate it from the olivary body. Each area bears a pear-shaped prominence—THE ANTERIOR PYRAMID (fig. 29 and 32, a.p.)—which is broader above than below, though it becomes slightly constricted, before disappearing beneath the transverse fibres of the pons. These pyramids will afterwards be traced to the cerebral peduncles, and thence to the cerebral hemispheres (fig. 32 and 33). To their constitution you will require to give your closest attention, for it is somewhat complicated.

PLATE 9.

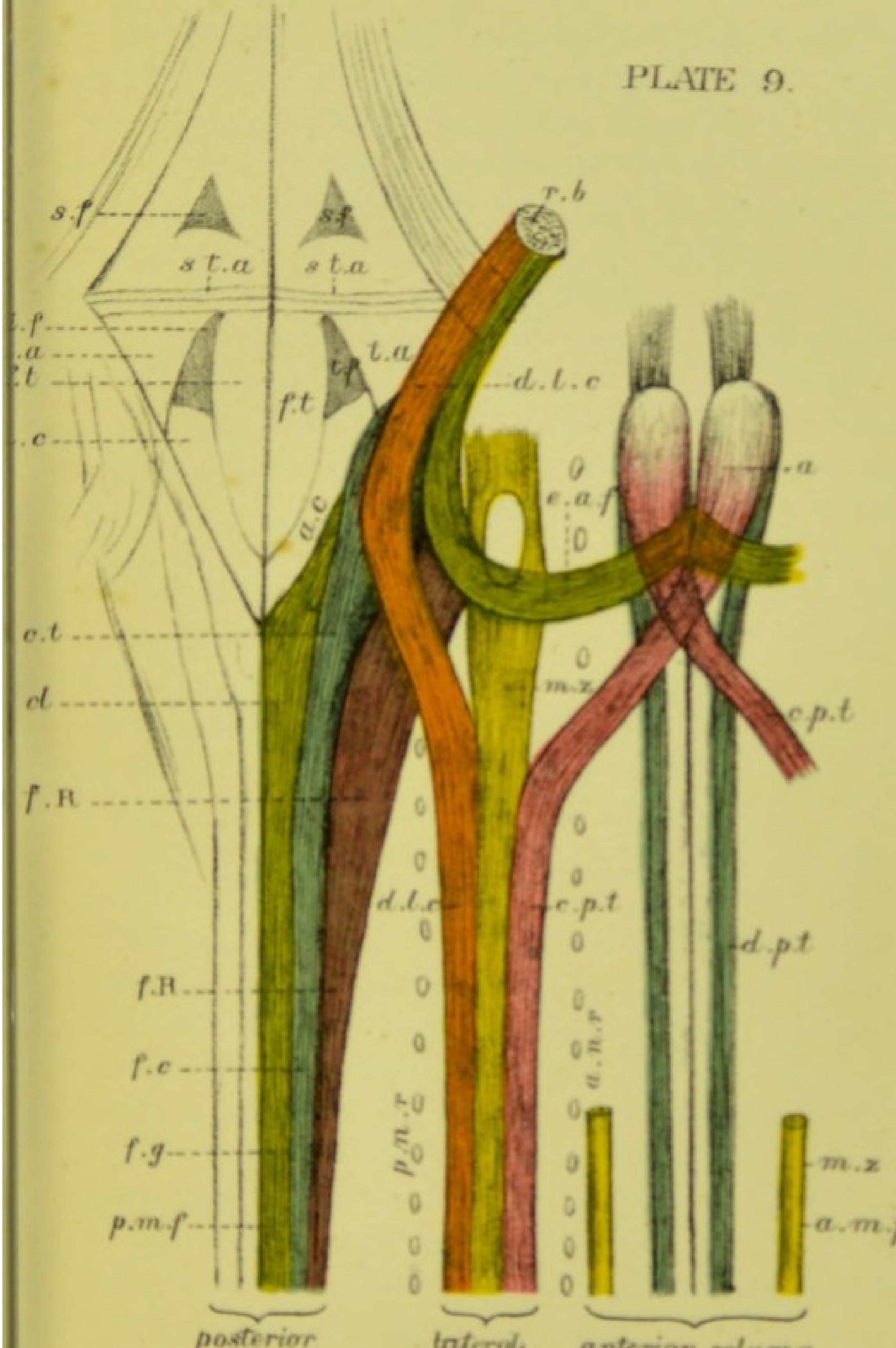


Fig. 33.

of the hemisphere to its lower margin (fig. 47, page 76, dotted line). The other boundaries of the external surface are the margins of the hemisphere. Two transverse sulci divide the surface into three antero-posterior convolutions, a SUPERIOR, a MIDDLE, and an INFERIOR OCCIPITAL (fig. 47, page 76, s.m.i.oc.); but these are by no means constant.

The occipital lobes probably contain centres connected with sight.

IV. The **Temporo-sphenoidal Lobe,** occupying the middle fossa at the base of the skull, is conical in shape and has three surfaces—an *upper*, a *lower*, and an *external* or lateral.

The *external surface* is bounded above by the HORIZONTAL LIMB of the FISSURE OF SILVIUS, which separates it from the parietal lobe; below by the INFERIOR TEMPORO-SPHENOIDAL SULCUS, which separates it from the under surface. Behind there is no definite line of demarcation between it and the outer surface of the occipital lobe, the line prolonged downwards from the external parieto-occipital fissure serving as its limit. This surface has three transverse fissures—the SUPERIOR (or PARALLEL), the MIDDLE, and the INFERIOR TEMPORO-SPHENOIDAL—the upper two sulci separate from each other the SUPERIOR, the MIDDLE, and the INFERIOR TEMPORO-SPHENOIDAL CONVOLUTIONS. The inferior fissure is, as we have said, the boundary between the outer and the lower surface.

The *upper surface* is hidden within the fissure of Sylvius, and is marked out by somewhat inconstant sulci into two or three indefinite gyri.

The *inferior surface* presents a depression caused by the upper margin of the petrous part of the temporal bone, and this may be taken as the limit between this lobe and the occipital; the part in front of the groove being convex and belonging to the temporo-sphenoidal lobe; the part behind the groove being concave, and belonging to the occipital lobe. These two parts are taken together, and their convolutions are two in number — a SUPERIOR and an INFERIOR OCCIPITO-TEMPORAL CONVOLUTION (fig. 49, sup. and inf.occ.-temp., page 78) — separated from each other by the COLLATERAL FISSURE (fig. 49, coll.f.).

IV. The **Central Lobe** (Insula, Isle of Reil), the first to be developed, lies deeply within the fissure of Sylvius, and cannot be seen unless you separate the sides of that fissure. Triangular in shape, it consists of five or six convolutions, called GYRI OPERTI (fig. 48, i.r., page 78), which are limited externally by a deep sulcus separating them from the adjacent convolutions—the OPERCULUM (fig. 48, op.), formed by the contiguous ends of the ascending frontal, ascending parietal, and the inferior frontal convolutions. In front and behind, the Isle of Reil is separated by well-marked sulci from the frontal and temporo-sphenoidal lobes respectively (fig .48).

V. **Fissures and Convolutions of the Median Surface of the Hemispheres** (fig. 49, page 78).—Most of the convolutions of this surface are parts of lobes already described, but it will be well to group them together under the above heading. To examine them you will require a mesial vertical section of the Hemispheres.

Arching through this aspect of each hemisphere is seen the cut surface of the CORPUS CALLOSUM (fig. 49, page 78), which we shall take as our guide to the study of the gyri and sulci.

1. The CALLOSAL FISSURE (ventricle of the corpus callosum) (fig. 49, call.f.).—This fissure runs along the upper margin of the corpus callosum and then turns round its posterior extremity to end in the notch of the *uncus* (fig. 49). Between it and the upper margin of the hemisphere lies the CALLOSO-MARGINAL FISSURE (fig. 49, call.mar.), which, commencing in front beneath the anterior end of the corpus callosum extends backwards, parallel to the margin of the hemisphere, to a level with the hinder end of the corpus callosum, when it turns upwards to the mesial margin of the hemisphere, a little behind the fissure of Rolando (fig. 49). The original direction of the calloso-marginal fissure is continued by a small sulcus which, along with the calloso-marginal, separates the GYRUS FORNICATUS below, from the MARGINAL CONVOLUTION above.

The GYRUS FORNICATUS (convolution of the corpus callosum), (fig. 49), commences in front below the anterior end of the corpus callosum, and arching backwards round its posterior end becomes slightly constricted—the isthmus—and then runs downwards and forwards on the mesial edge of the temporo-sphenoidal lobe, as the SUPERIOR OCCIPITIO-TEMPORAL CONVOLUTION or GYRUS HIPPOCAMPI, or UNCINATE

GYRUS, from the hook-like process—uncus—in which it ends in front (fig. 49, sup.occ.temp.).

N.B.—There is no little confusion in the naming of these convolutions. Thus the superior occipito-temporal is often called the *uncinate* gyrus. Again, either the whole convolution, or only the posterior part of it, viz., that near the hinder end of the corpus callosum, is known as the Hippocampal Convolution; while the part beneath the calcarine fissure—or at other times the whole gyrus—is called the Lingual lobe. The inferior occipito-temporal convolution is often called the Fusiform lobe, though this name also is sometimes confined to the posterior part of that gyrus.

The MARGINAL CONVOLUTION (fig. 49), belonging to the mesial surface of the frontal lobe, begins at the anterior perforated spot, and running along the upper edge of the hemisphere above the calloso-marginal sulcus becomes continuous above with the superior frontal convolution. Inferiorly it passes into the gyrus rectus of the orbital surface, and posteriorly it is limited by the vertical part of the calloso-marginal fissure (fig. 49). The hinder part of the marginal gyrus is called the PARACENTRAL LOBULE (fig. 49); it is the mesial aspect of the ascending frontal convolution.

The INTERNAL PARIETO-OCCIPITAL FISSURE (fig. 49, i.par.occ.) lies behind the vertical part of the CALLOSO-MARGINAL FISSURE, the two enclosing between them the mesial surface of the parietal lobe, called the QUADRATE LOBE or PRÆCUNEUS (fig. 49).

Below the internal parieto-occipital fissure will be seen the CALCARINE SULCUS (fig. 49), which runs forwards from the posterior border of the hemisphere to join the INTERNAL PARIETO-OCCIPITAL SULCUS.

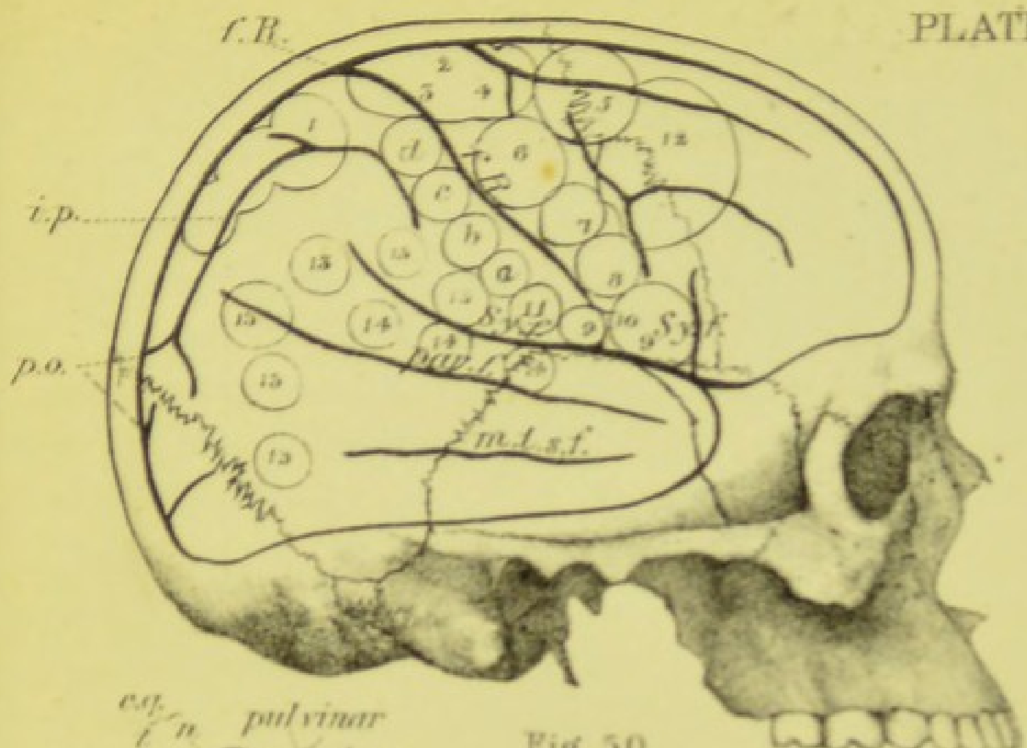


Fig. 50.

Fig. 51.

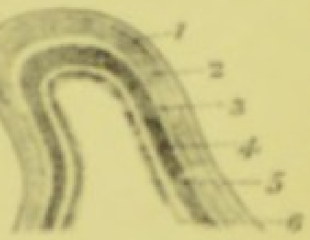


Fig. 52.

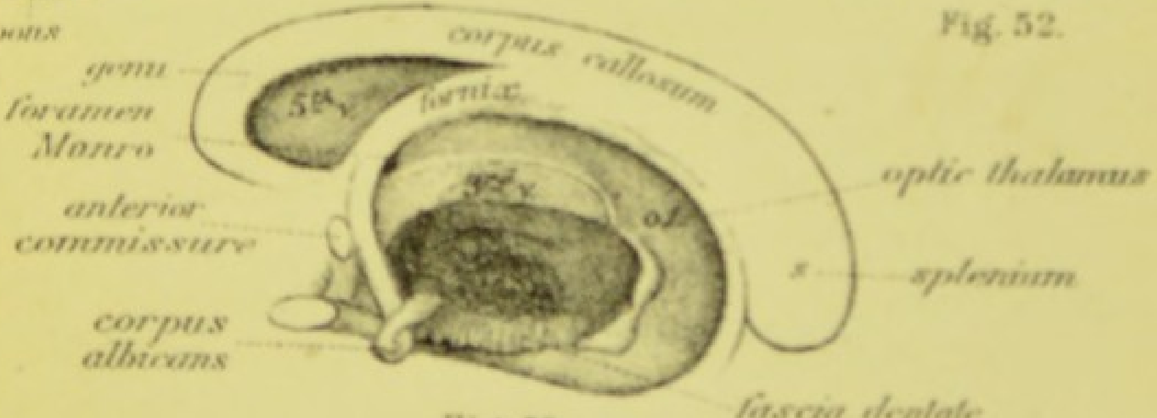


Fig. 53.


Fig. 54.

They together enclose the wedge-shaped mesial aspect of the occipital lobe, called the CUNEUS (fig. 49).

The DENTATE (hippocampal) FISSURE (fig. 49) continuous behind with the callosal sulcus, ends in front as we have already seen in the notch of the uncus. This fissure separates the UNCINATE OR HIPPOCAMPAL GYRUS from the FIMBRIA OR TÆNIA HIPPOCAMPI (see page 95).

The DENTATA CONVOLUTION OR FASCIA DENTATA is a notched gyrus, the free edge of the superficial grey matter of the hemisphere (fig. 62, page 102), and lies at the bottom of the dentate fissure.

Passing into the lateral ventricles, through the great transverse fissure above the FIMBRIA, is a vascular inflection of pia mater known as the CHOROID PLEXUS of the lateral ventricles (see p. 100).

Both Fascia Dentata and Fimbria blend below with the substance of the uncus.

TABLE OF THE CONVOLUTIONS OF THE MESIAL SURFACE.

Convolutions of mesial surface.	Gyrus fornicatus. Marginal. Hippocampal (uncinate). Dentate. Quadrate (Præcuneus). Cuneus. Paracentral lobule.

STRUCTURE OF THE CEREBRAL CORTEX.—The grey matter of the cortex consists of neuroglia, of nerve fibres and nerve cells, and blood-vessels.

With the naked eye six layers can be distinguished (fig. 52, page 84). Microscopically five layers are usually described, but their limits and their relations to each other are by no means defined (fig. 54, page 84).

The 1ST LAYER—the most external—is chiefly composed of neuroglia with a thin stratum of white nerve fibres on the surface beneath the pia mater.

The 2ND LAYER consists of small nerve cells mostly pyramidal, and having numerous branched processes.

The 3RD LAYER is made up of large and small pyramidal branching cells, with their pointed ends towards the surface. They are separated by radiating nerve fibres into more or less definite groups.

The 4TH LAYER consists of small irregular cells with many fine processes.

The 5TH LAYER consists chiefly of fusiform cells, which, at the apex of the gyrus, are set at right angles to the surface, but in the sulci are parellel to it. In the regions of the motor areas (fig. 50, page 84), especially in the ascending frontal convolutions, the nerve cells are of large size, and are arranged in groups. They are called GIANT CELLS, GANGLIONIC CELLS, cells of Betz, and may probably be trophic in nature (1st trophic region).

Next the innermost layer of the cortex comes the white medullary centre, many of the fibres of which probably end in the axis cylinder processes of the pyramidal cells; others form a plexus at the base of the 2nd and 3rd layers of cells.

The RELATIONS OF THE CONVOLUTIONS AND FISSURE to the BONES AND SUTURES of the skull are indicated in fig. 50, page 84.

II. BASE OF THE CEREBRUM.

On the Base of the Brain, between the great longitudinal fissure in front, the under surface of the Frontal and Temporo-sphenoidal lobes on each side, and the Crura Cerebri behind (fig. 48, page 78), is enclosed an irregular-shaped interval—the **Inter-peduncular space,** within which are contained, besides the CIRCLE OF WILLIS, the following structures. Commencing in front, at the longitudinal fissure, we see (*a*) the ANTERIOR END of the CORPUS CALLOSUM—the ROSTRUM—hidden within the fissure, and passing backwards and outwards from it, towards the fissure of Sylvius, are two narrow white bands, (*b*) the PEDUNCLE OF THE CORPUS CALLOSUM (fig. 24, page 24, and fig. 48, page 78), between which lies a thin grey lamina, (*c*) the LAMINA CINEREA. Passing across the middle line, behind the median fissure, is a flattened white band, (*d*) the OPTIC COMMISSURE (fig. 24, page 24, and fig. 48, page 78), which passes forwards at the sides into two rounded bundles, (*e*) the OPTIC NERVES (figs. 24 and 48), and backwards as flattened white bands, (*f*) the OPTIC TRACTS (figs. 24 and 48), which curve inwards round the outer sides of the crura cerebri. External to the optic commissure, at the root of the fissure of Sylvius, and behind the olfactory peduncles, are two triangular shallow depressions, one on each side—the ANTERIOR PERFORATED SPOTS (fig. 24 and 48), greyish laminæ for the passage of blood-vessels into the interior of the brain. At the sides these perforated grey laminæ are continuous with the lamina cinerea, and across them pass the peduncles of the corpus callosum. Behind the optic commissure is a small grey elevation, (*g*) the TUBER CINEREUM (figs. 24 and 48), which is continuous beneath (in this position of the brain) the optic commissure with the lamina cinerea. Projecting downwards from the tuber cinereum is a funnel-shaped process, (*h*) the INFUNDIBULUM (figs. 24 and 48), to the apex of which is attached (in the entire brain) the posterior of the two lobes of the (*i*) PITUITARY BODY. This body was left in the Sella Turcica when removing the brain. It is of a reddish colour, and consists of two lobes, an anterior, which in structure resembles the thyroid body, and a posterior, which is at first hollow, but subsequently becomes solid.

Behind the tuber cinereum, between it and the crura cerebri, are two small rounded white pea-shaped nodules, (*j*) the CORPORA ALBICANTIA (figs. 24 and 48), which we shall afterwards see are closely connected with the anterior pillars of the fornix (fig. 53, page 84). Behind the corpora albicantia, and between the diverging cerebral peduncles, lies (*k*) the POSTERIOR PERFORATED SPOT—Pons Tarini (fig. 24)—a grey lamina similar to the anterior perforated spot, and, like it, for the passage of blood vessels into the interior of the cerebrum.

Besides the above structures there will be seen, on the inferior aspect of the Brain, the superficial origins of the cranial nerves (fig. 48, page 78). They are—(*a*) OLFACTORY NERVES, 1st pair; (*b*) the OPTIC, 2nd pair; (*c*) the 3RD NERVES; (*d*) the 4TH NERVES;

(*e*) the 5TH NERVES; (*f*) the 6TH NERVES; (*g*) the 7TH NERVES, (i) *facial* part (7th), and (ii) the *auditory* part (8th); (*h*) the 8TH NERVES, (i) *glossopharyngeal* (9th), (ii) the *vagus* (10th), and (iii) the *spinal accessory* (11th); (*i*) the 9TH HYPOGLOSSAL (12th). For further account of these nerves see page. 115. Superficial and Deep Origins of the Cranial Nerves.

III. INTERIOR OF THE CEREBRUM.

When we examine by means of horizontal sections the interior of the cerebrum, we find that, above the level of the corpus callosum, each hemisphere consists of a solid white central core—*centre ovale*—surrounded externally by a wavy edge of grey matter—the *cerebral cortex.*

VENTRICLES.—Below the level of the corpus callosum, however, the centre of the cerebrum is occupied by an irregular cavity, the remains of the original cerebrospinal embryonic canal (see Chap. III., Development). This cavity, somewhat T-shaped in coronal section (fig. 60 and 61, page 102), is subdivided by partitions or septa into smaller spaces called ventricles; thus we have (*a*) the 3RD VENTRICLE—a vertical mesial cleft-like space, represented by the upright part of the T, lying beneath the corpus callosum, and extending below to the base of the brain; and (*b*) the LATERAL VENTRICLES, two lateral diverticula, the cross stroke of the T—hollowed out in the substance of the hemispheres. Uniting these various ventricles with each other are narrow passages or channels, constricted portions of the same tube from which the brain and spinal cord were developed. Thus, in front is the FORAMEN of MUNRO, which connects the lateral ventricles with the 3rd ventricle and with each other (fig. 56, page 94, and fig. 58, page 98); and behind is the AQUEDUCT of SYLVIUS, or iter a tertio ad quartum ventriculum (fig. 58).

BASAL GANGLIA.—Besides the central cavity, which corresponds to the central canal of the spinal cord, the interior of the cerebrum is occupied by large ganglionic masses—the Basal Ganglia—viz., the CORPORA STRIATA and the OPTIC THALAMI, so that each hemisphere forms a kind of shell enclosing and overlapping the Basal Ganglia. Other smaller ganglionic masses are the CORPORA QUADRIGEMINA and the CORPORA GENICULATA

COMMISSURES.—Finally uniting the cerebral hemispheres and their ganglia are transverse and longitudinal bands or commissures—the CORPUS CALLOSUM, the ANTERIOR, POSTERIOR, and MIDDLE COMMISSURES, and the FORNIX.

We shall describe (1) the VENTRICLES, their communications and septa; (2) the BASAL GANGLIA and the CORPORA QUADRIGEMINA or GENICULATA; (3) the COMMISSURES—the Corpus Callosum, the Fornix, and the three Minor Commissures; but before doing so we shall give seriatim the dissections required to expose these several parts, so that the subsequent description may be less disconnected and the more easily understood.

DISSECTION.—*A*. To expose the Corpus Callosum.—Place the Brain upon its base with the convex surface uppermost.

With a large sharp knife, moistened in spirit, cut from the right hemisphere a horizontal slice about ½ an inch in thickness. This will expose an oval-shaped central white mass of nervous substance in each hemisphere—the *centre ovale* minus, studded here and there with small red spots—*puncta vasculosa*—the cut ends of the blood vessels. Surrounding the white centre is the wavy grey edge, about ⅛ of an inch thick, the cerebral cortex before referred to.

Remove a series of slices similar to the first, until you reach the level of the upper surface of the corpus callosum, then, with one sweep of the knife, cut off the opposite hemisphere to this same level, when you will see the *centre ovale magus* (under which term is included the whole area now exposed). The upper surface of the corpus callosum is marked by a mesial groove, the *raphé*, and by median and lateral *longitudinal striæ*. Procure, if possible, a second brain, and make a mesial section of it, to enable you the better to examine the corpus callosum and the parts beneath.

B. **To expose the Lateral Ventricles.**—(*a*) The **Body.**—Cut through the corpus callosum a little on each side and parallel to the middle line, and with the back of the knife raise its fibres, being careful not to injure the parts seen in the floor of the cavity beneath. These enumerated from before backwards are—(1) the NUCLEUS CAUDATUS (fig. 55, page 92); (2) the TÆNIA SEMICIRCULARIS (fig. 55); (3) the OPTIC THALAMUS (fig. 55); (4) the CHOROID PLEXUS (fig. 55); (5) and the edge of the FORNIX (fig. 55).

(*b*) **Cornua.**—Next trace the cavity, forwards and outwards, as it winds round the front of the caudate nucleus into the frontal lobe—this is the ANTERIOR HORN: then follow it backwards into the occipital lobes—the POSTERIOR HORN; and downwards and outwards into the temporo-sphenoidal lobe—the DESCENDING OR LATERAL HORN.

In the posterior horn you will see the HIPPOCAMPUS MINOR (fig. 56 and 57, page 54); in the descending horn, the HIPPOCAMPUS MAJOR, the PES HIPPOCAMPI (fig. 56), the TÆNIA

HIPPOCAMPI (fig. 57), and part of the CHOROID PLEXUS of the lateral ventricles (fig. 57).

C. **To expose the Fornix, the Septum Lucidum, and the 5th Ventricle** (figs. 56 and 57).—Make a transverse incision through the centre of the corpus callosum, and turn its ends backwards and forwards. Pass a sharp knife along the fore part of the under aspect, and sever the septum lucidum. Lift up the anterior part of the corpus callosum, when you will expose the SEPTUM LUCIDUM, and the cavity enclosed between its two layers—the 5TH VENTRICLE. Next reflect the posterior half of the corpus callosum, detaching it with the greatest care from the subjacent fornix where they are blended together. This will expose the BODY OF THE FORNIX.

D. **To expose the Velum Interpositum and the 3rd Ventricle** (fig. 57 and 58, page 98).—Cut transversely through the middle of the Fornix, and turn back the cut ends; the VELUM INTERPOSITUM, a delicate process of pia mater, will thus be brought into view. Examine this velum, and then detach it in front and throw it back, so that it may be again replaced if needed. The 3RD VENTRICLE will be seen beneath it, extending to the base of the brain between the optic thalami. In front are the ANTERIOR COMMISSURE, the ANTERIOR PILLARS OF THE FORNIX, and the FORAMEN OF MUNRO; behind are the PINEAL GLAND and its PEDUNCLES; the CORPORA QUADRIGEMINA, and the AQUEDUCT OF SYLVIUS; while crossing the space is the MIDDLE COMMISSURE.

I. VENTRICLES OF THE BRAIN.

The VENTRICLES of the Brain are five in number; four, viz., the two LATERAL (1st and 2nd), the THIRD and the FOURTH ventricles are the remnants of the cerebrospinal embryonic canal, and are continuous with each other and with the ventricles of the spinal cord. The 5TH VENTRICLE, on the other hand, belongs to a different category to the rest, and the term

PLATE 16.

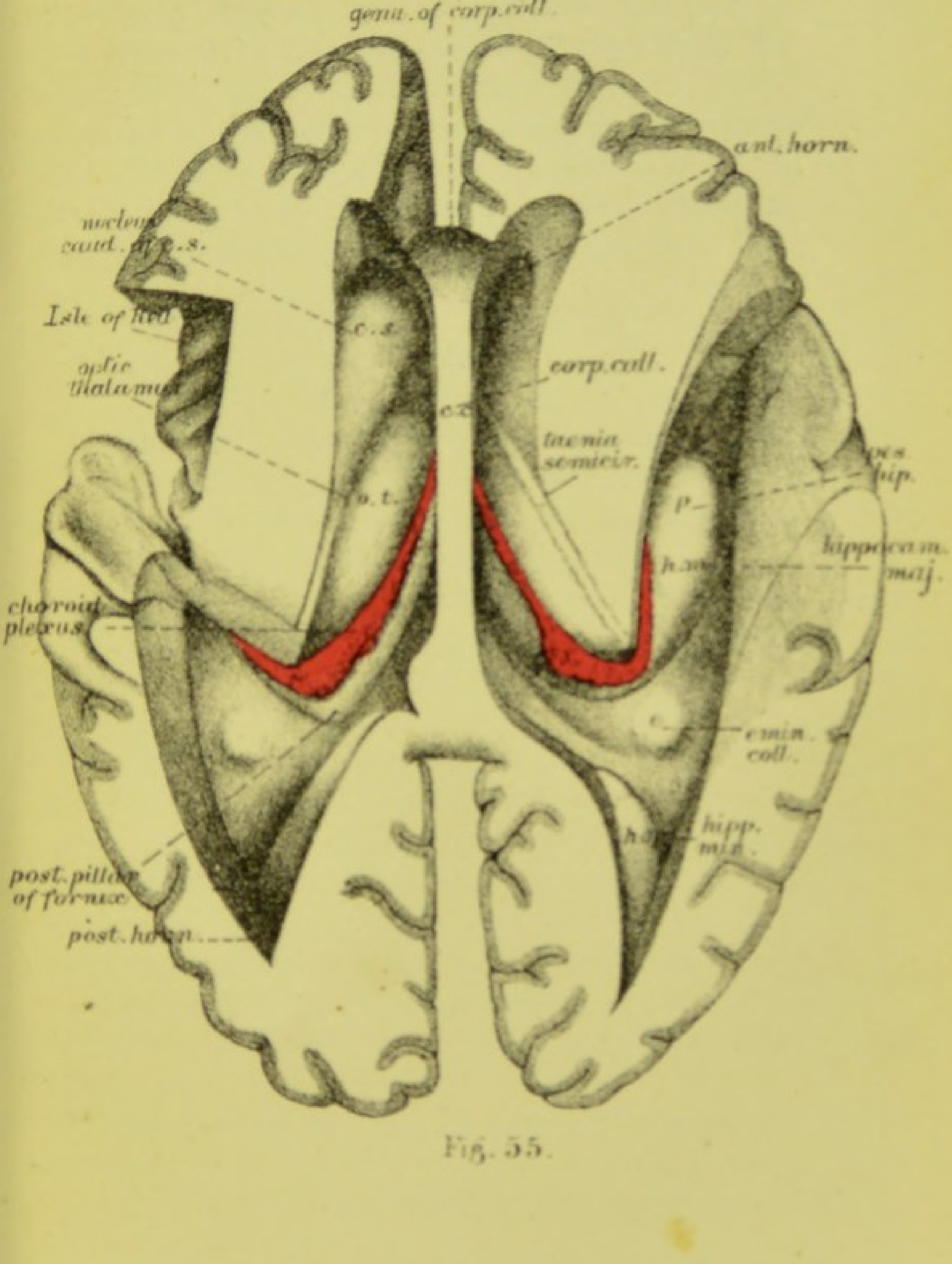


Fig. 55.

PLATE 17.

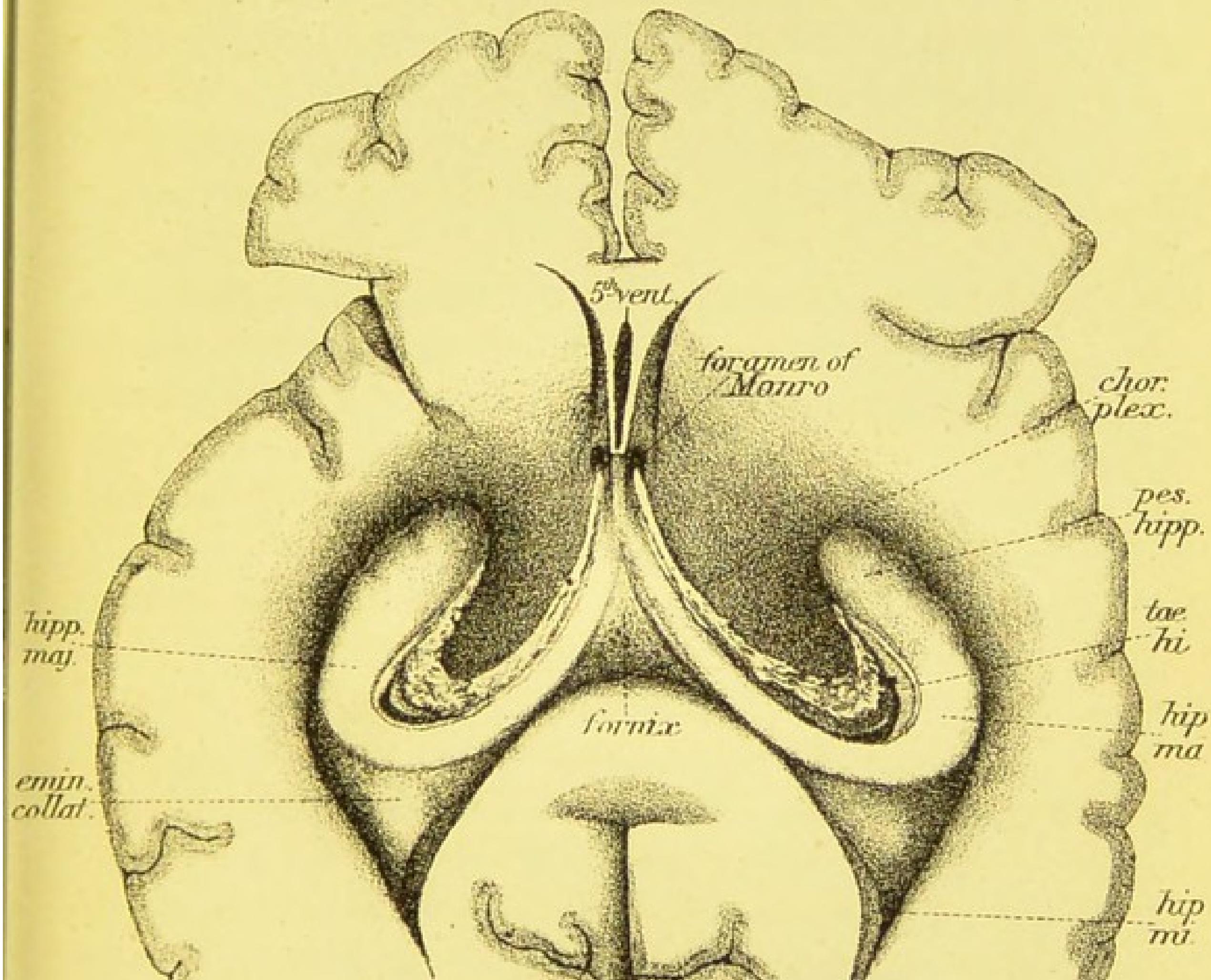


Fig. 56.

eminence—the NUCLEUS CAUDATUS of the corpus striatum; (3) an oval grey mass—the upper surface of the OPTIC THALAMUS, which is separated from the nucleus caudatus by a shallow groove in which lies (4) the TÆNIA SEMICIRCULARIS. Resting on the optic thalamus is (5) the vascular fringe—the CHOROID PLEXUS of the lateral ventricles; and, finally, close to this fringe, nearer the middle, is (6) the thin sickle-shaped free edge of the BODY OF THE FORNIX.

iii. The *inner wall* of the ventricle is formed by a thin double vertical mesial partition—the SEPTUM LUCIDUM, which extends between the corpus callosum and the fornix.

iv. *Externally* the floor and wall meet in the mass of the hemispheres.

The **Cornua of the Ventricles** are, as we have said, three in number, anterior, posterior, and lateral (fig. 55, page 92).

(i.) The **Anterior Horn** is a short triangular horn-shaped cavity, which passes forwards and outwards from the fore part of the body of the ventricle round the anterior end of the nucleus caudatus into the substance of the frontal lobe.

Its *roof* and *anterior wall* are formed by the CORPUS CALLOSUM; its *floor* by the substance of the FRONTAL LOBE; while both *behind* and *below* is the NUCLEUS CAUDATUS.

ii. The **Posterior Horn** is a similar recess, passing outwards and backwards into the substance of the occipital lobe.

Its *roof* is formed by the CORPUS CALLOSUM; its

PLATE 17.

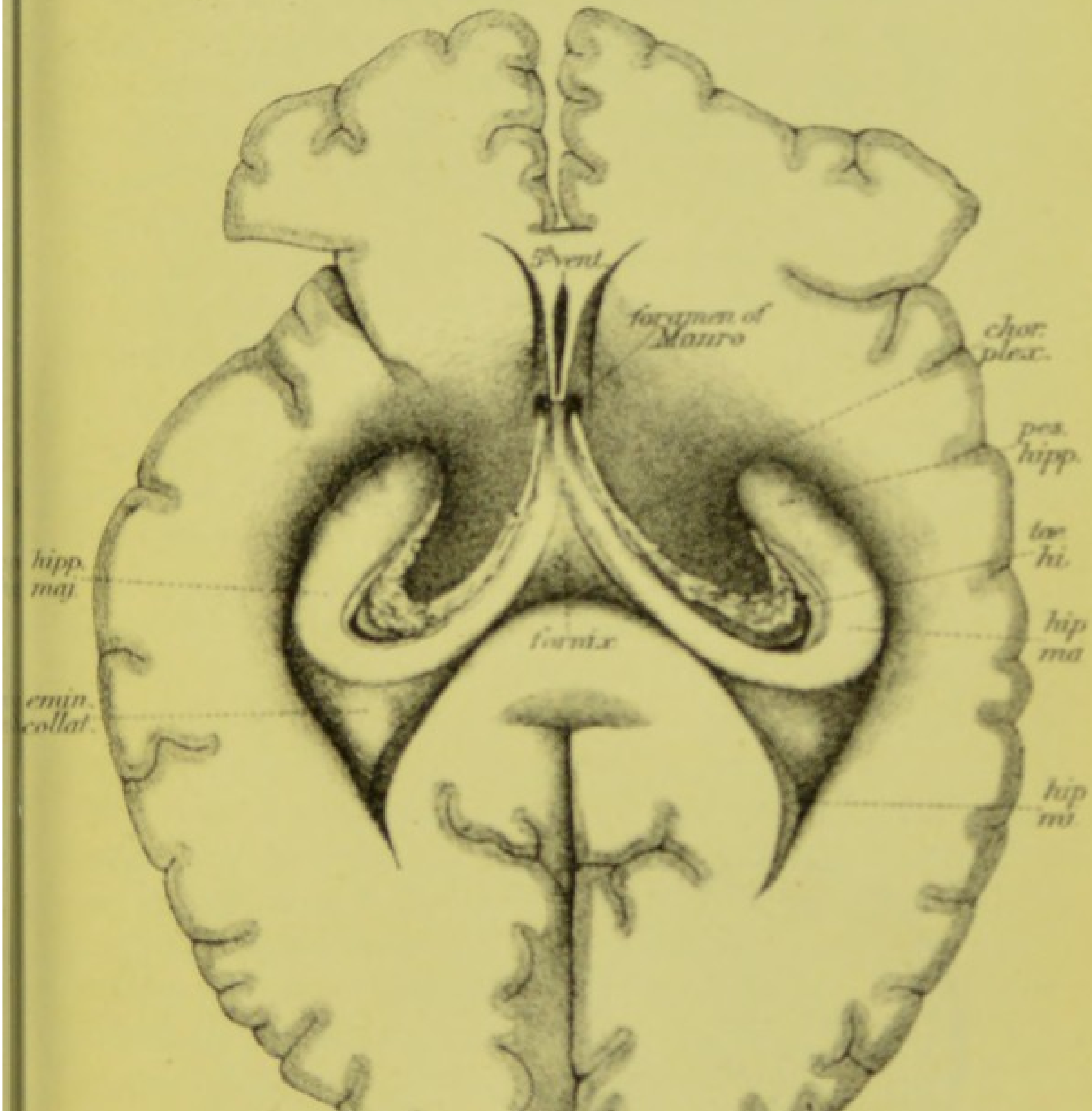


Fig. 56.

floor by an oval prominence—the HIPPOCAMPUS MINOR (fig. 56, page 94), caused by the calcarine sulcus on the surface of the hemisphere.

iii. The **Lateral Horn** (descending horn) curves round the posterior end of the optic thalamus as a bent finger-like passage, which runs first backwards and outwards, then downwards, forwards, and finally inwards (B.O.D.F.I.) in the substance of the temporo-sphenoidal lobe.

In its *roof* are—(*a*) the CORPUS CALLOSUM; (*b*) the posterior extremity of the OPTIC THALAMUS; (*c*) the tapering end of the NUCLEUS CAUDATUS; (*d*) the TÆNIA SEMICIRCULARIS.

In the *floor* of the passage lies a curved elongated projection, following the bend of the horn, and called the HIPPOCAMPUS MAJOR. This prominence is caused by the hippocampal (dentate) fissure on the surface of the brain. Below, at the apex of the horn, the HIPPOCAMPUS ends in an enlarged, grooved, paw-like, extremity—the PES HIPPOCAMPI; while along its inner concave margin lies a thin, white, tapering band of fibres—the TÆNIA HIPPOCAMPI or FIMBRIA, the prolongation of the posterior pillars of the Fornix. Above the fimbria in the CHOROID PLEXUS of the lateral ventricles, which here enters the ventricular cavities through the *great transverse fissure*, and below the fimbria is the free edge of the grey matter of the cortex. From the notched appearance caused by the mode of entrance over this free edge of the choroidal artery this part of the grey matter is called the FASCIA DENTATA. This artery carries with it into the lateral ventricles the process of pia mater—the *velum interpositum*—in the free margin of which it breaks up into the choroid plexus of the lateral ventricles (see velum interpositum).

At the point where the lateral and posterior horns diverge from each other you will see a slight eminence—the EMINENTIA COLLATERALIS (fig. 56, page 94)—caused by the collateral fissure on the surface.

Ependyma Ventriculorum. — The lateral ventricles are lined by a layer of neuroglia, covered on the surface by columnar ciliated epithelium, continuous with the epithelium of the other ventricles.

Communications.—The two lateral ventricles communicate with each other and with the 3rd ventricle through the FORAMEN of MUNRO, which lies between the anterior pillars of the fornix and the optic thalami (fig. 53, page 84). Inferiorly, this passage is single and mesial where it leads into the 3rd ventricle, but above it is bifid, consisting of two limbs, right and left, one passing to each lateral ventricle. Through this foramen, as we shall afterwards see, the choroid plexuses of the lateral ventricles become continuous with those of the 3rd ventricle.

THE 3RD VENTRICLE.

(Dissection, page 92.)

The 3RD VENTRICLE (fig. 58, page 98, and fig. 60 and 61, page 102) is the narrow, vertical, cleft-like space, situated in the middle line between the optic thalami. It lies beneath the body of the fornix and

PLATE 18.

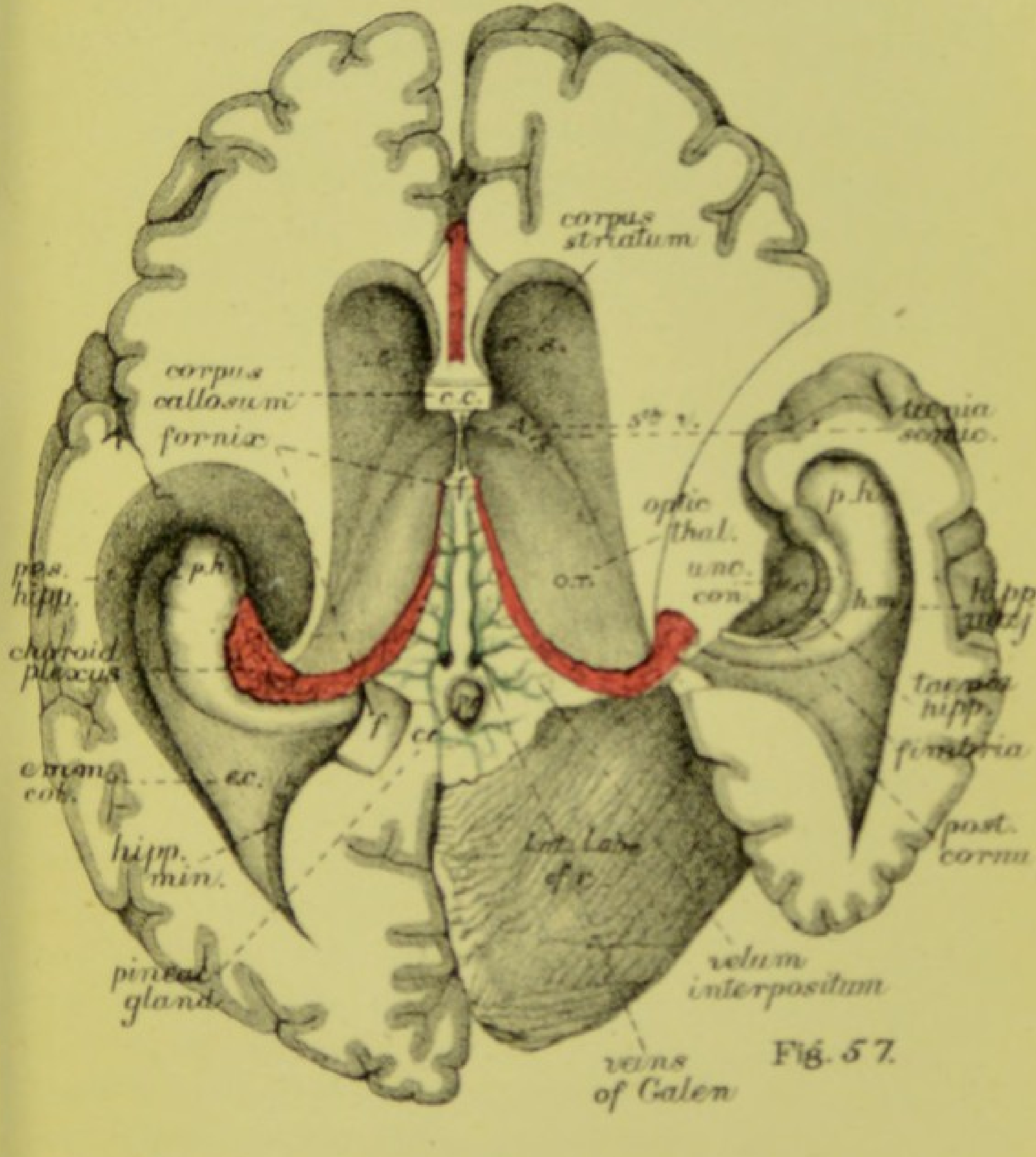


Fig. 57.

extends down to the base of the brain, being deeper in front than behind.

Boundaries.—The *roof* is formed by the VELUM INTERPOSITUM, covered on its under surface by a layer of flattened epithelial cells.

In its *floor* are the structures contained within the Interpeduncular space at the base of the brain (fig. 48, page 78), viz., (1) the LOCUS PERFORATUS POSTICUS; (2) the CORPORA ALBICANTIA; (3) the TUBER CINEREUM; (4) the INFUNDIBULUM; (5) the OPTIC COMMISSURE; and (6) the LAMINA CINEREA.

In *front* the ventricle is limited by the ANTERIOR PILLARS of the FORNIX and the ANTERIOR COMMISSURE: *behind*, by the POSTERIOR COMMISSURE and the AQUEDUCT of SYLVIUS, above which is the PINEAL GLAND and four rounded nodules—the CORPORA QUADRIGEMINA. At the *sides* the walls of the cavity are formed by the OPTIC THALAMI, along each of which runs a bundle of white fibres—the PEDUNCLES of the PINEAL GLAND. Crossing the centre of this space, between the optic thalami, is a broad, grey band—the middle, soft, or GREY COMMISSURE.

The 3rd ventricle is lined by epithelium similar to, and continuous with, that of the other ventricles. On the roof, however, the epithelium is flattened, and follows all the folds of the vascular fringes—the choroid plexuses—which hang down along the middle line from the under surface of the velum interpositum. The lateral walls of the ventricle are covered by a layer of ependyma, and the floor consists of grey matter continuous with the grey matter of the Aqueduct of Sylvius. At the posterior perforated spot, and at the tuber cinerea and lamina cinerea, this grey matter comes to the surface at the base of the brain.

Communications.—The 3rd ventricle communicates in front, through the FORAMEN of MONRO, with the lateral ventricles; behind, through the ACQUEDUCT OF SYLVIUS, with the 4th ventricle; and below, at the fore part of the floor, by a conical-shaped passage with the infundibulum—ITER AD INFUNDIBULUM.

The **Aqueduct of Sylvius** is the narrow passage between the 3rd and 4th ventricles (fig. 58, page 98). Above it is roofed over by a thin lamina—lamina quadrigemina—so called because it supports the corpora quadrigemina (see page 104). Its floor and lateral walls are formed by the dorsal part of the cerebral peduncles (see page 110, and fig. 40, page 60). Internally it is lined by ciliated columnar epithelium, outside which is a thick layer of grey matter continuous with that (locus cæruleus) of the 4th ventricle. From this grey matter arises the 3rd, the 4th, and part of the 5th nerves (see page 116).

The **SEPTUM LUCIDUM** (dissection, page 92) is the thin, double, vertical, mesial, partition which separates the lateral ventricles from each other (fig. 58, page 98, and fig. 53, page 84). Triangular in shape, it fills up the interval between the concavity of the knee-shaped bend of the corpus callosum and the front of the fornix. Broader in front than behind, it gradually tapers to a point where the corpus callosum and fornix come in contact with each other, and it contains, between the two layers of which it is com-

oppos anter. horn

PLATE 19.

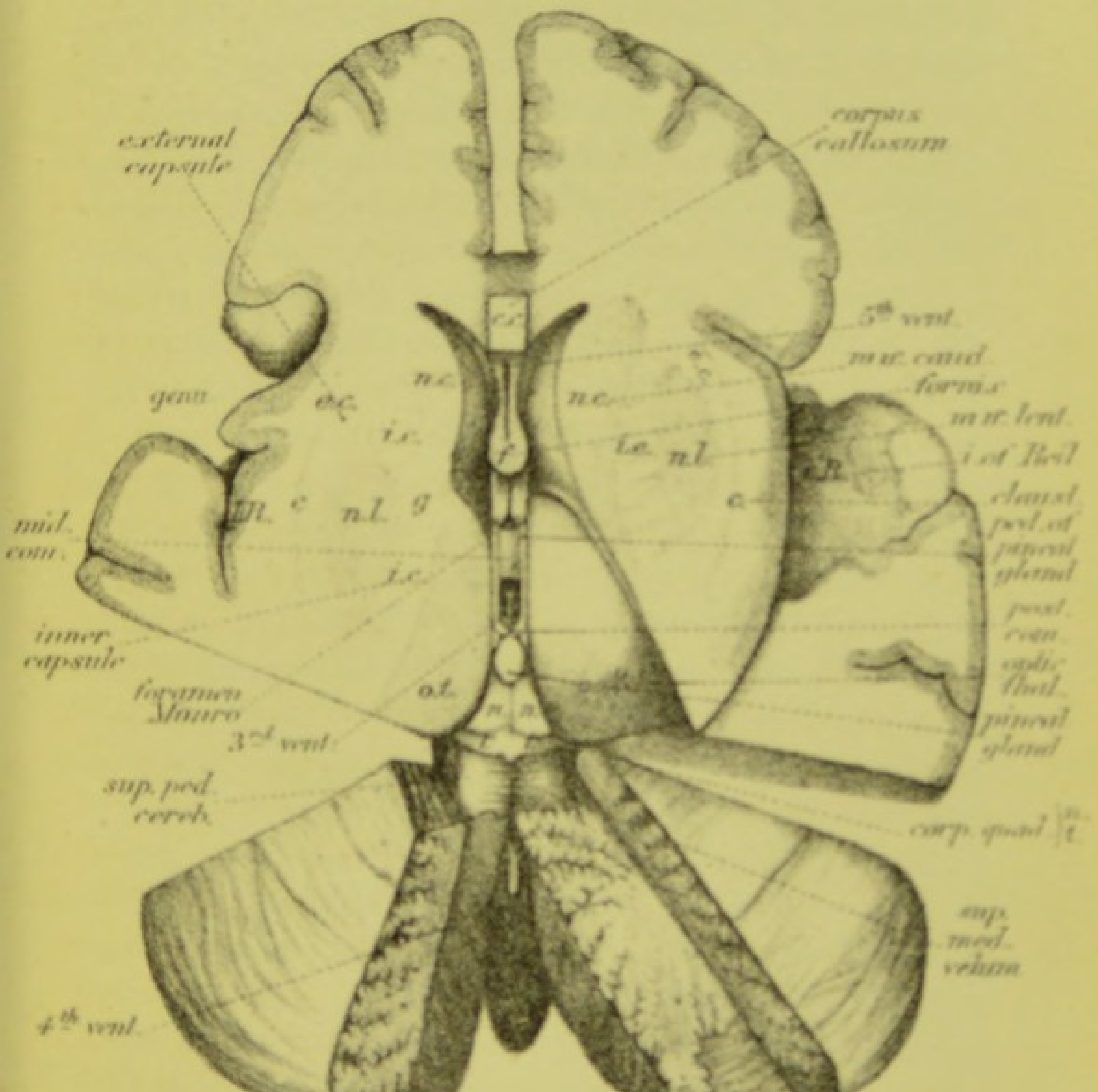


Fig. 58.

posed, a narrow slit-like cavity—the 5TH VENTRICLE, or ventricle of the septum. Externally, each layer of the septum consists of grey matter, derived originally from the grey matter of the hemisphere, and covered, on the surface next the cavity of the lateral ventricles, by a layer of epithelium and ependyma. Internally, next the cavity of the 5th ventricle, each layer of the septum is composed of white nerve substance, representing the medullary part of the hemispheres. As already stated, the cavity of the 5th ventricle is not lined by epithelium like the other ventricles, nor, in the adult, does it in any way communicate with them.

The **VELUM INTERPOSITUM** (dissection, page 92) is a thin horizontal partition, which, as you already know, roofs over the 3rd ventricle, and appears in the floor of the lateral ventricles (fig. 57, page 96). It is the central part of pia mater which penetrates the lateral ventricles through the great transverse fissure of the cerebrum. Triangular in shape, with the apex forwards, the velum has the same extent as the body of the fornix, so that it reaches from the foramen of Monro in front to the splenium behind, beneath which, after investing the pineal gland, it passes to become continuous with the rest of the pia mater on the cerebrum and cerebellum. At the sides, the free edge of the velum projects into the floor of the lateral ventricles, and rests on the upper surface of the optic thalami, round the hinder ends of which it passes down the descending horns of the lateral ventricles, to become continuous with the pia mater at the base of the brain.

CHOROID PLEXUS (fig. 57).—Projecting downwards along the middle line of the under aspect of the velum are the two vascular fringes—the choroid plexuses of the 3rd ventricle, covered everywhere, however, by the epithelium which forms the roof of that cavity. In each lateral margin are similar vascular fringes—the choroid plexuses of the lateral ventricles, which extend from the foramen of Monro in front (through which they are continuous with the plexuses of the 3rd ventricle), to the apex of the descending cornu of the lateral ventricles, where the velum becomes continuous with the rest of the pia mater through the great transverse fissure.

These plexuses consist of tortuous ramifications of small blood-vessels, and are covered with vascular papillæ, over which is a layer of epithelium.

VEINS OF GALEN.—Along the centre of the upper surface of the velum interpositum run two veins side by side—the veins of Galen—which receive blood from the interior of the ventricles, and discharge it into the straight sinus.

THE GREAT TRANSVERSE FISSURE OF THE CEREBRUM.

The Great Transverse Fissure (fig. 57, page 96) is the large artificial cleft made into the lateral ventricles when the pia mater and choroid plexus, with the epithelium covering them, are torn away from the posterior part of the brain beneath the fornix, and from the descending cornua. The fissure thus formed is horse-shoe shaped; its central part corresponds to the base of the body fornix, its lateral parts to the descending horns of the lateral ventricles. Through this fissure the pia mater and choroid plexus enter the ventricles.

1. SUPERIORLY it is bounded (*a*) *near the middle line* by the posterior part of the corpus collosum and fornix; (*b*) *on each side* by the free margins of the hemisphere, viz., the Fimbria and the Fascia Dentata.

2. INFERIORLY it is bounded (*a*) *near the middle line* by the corpora quadrigemina and cerebral peduncles; (*b*) *on each side* by the posterior part of the optic thalami.

II. BASAL GANGLIA.*

I. The **Corpora Striata** are two in number, and are each subdivided into two parts—an INTRAVENTRICULAR portion, which appears in the floor of the lateral ventricles; and an EXTRAVENTRICULAR portion, hidden in the substance of the hemisphere.

The **Nucleus Caudatus**—the INTRAVENTRICULAR portion of the corpus striatum—so called from its shape, has been described as a pear-shaped, kite-shaped, pyriform or pyramidal eminence, of a pinkish grey colour, which appears in the fore part of the body of the lateral ventricles. Covered on the surface by a layer of white substance, each nucleus consist of a grey core streaked with white fibres, hence the name corpus striatum. Its larger end or head is directed forwards, and its posterior end or tail, gradually

* Under this term is sometimes included not only the corpora striata and optic thalami, but also the corpora quadrigemina, and geniculata, and the locus niger.

tapering to a point, pass backwards outside the optic thalamus into the roof of the descending horn of the lateral ventricle.

The **Nucleus Lenticularis**—the EXTRAVENTRICULAR part of the corpus striatum—can only be seen in sections of the hemispheres (fig. 58, page 98, and fig. 60, page 102). In horizontal sections it appears as a longitudinal grey mass, shaped like a double convex lens (lenticularis). It is placed external to the nucleus caudatus, and is separated from it by a strand of white nerve fibres, called the *inner capsule* (fig. 58, and see page 112). In vertical transverse section it is triangular in shape, and is intersected by two white laminæ, which divide it into three parallel strands of a somewhat different colour (fig. 60, page 102).

Claustrum.—External to the nucleus lenticularis will be seen a narrow band or streak of grey matter—the CLAUSTRUM—separated from the nucleus lenticularis by a white strand of fibres, the *outer capsule* (fig. 58, page 98, and see page 112), and from the contiguous grey matter of the Isle of Reil (figs. 58 and 60) by a second white strand. Thus, enumerated from within outwards, we have (1) the *nucleus caudatus*, (2) the *inner capsule*, (3) the *nucleus lenticularis*, (4) the *outer capsule*, (5) the *claustrum*, (6) a *strand of white fibres*, (7) the grey matter of the *Isle of Reil* (fig. 58, page 98).

The **Optic Thalami** are two large, oval, convex prominences placed above the crura cerebri, but behind and internal to the corpora striata from which they are separated by the Tænia Semicircularis. Forming

PLATE 20.

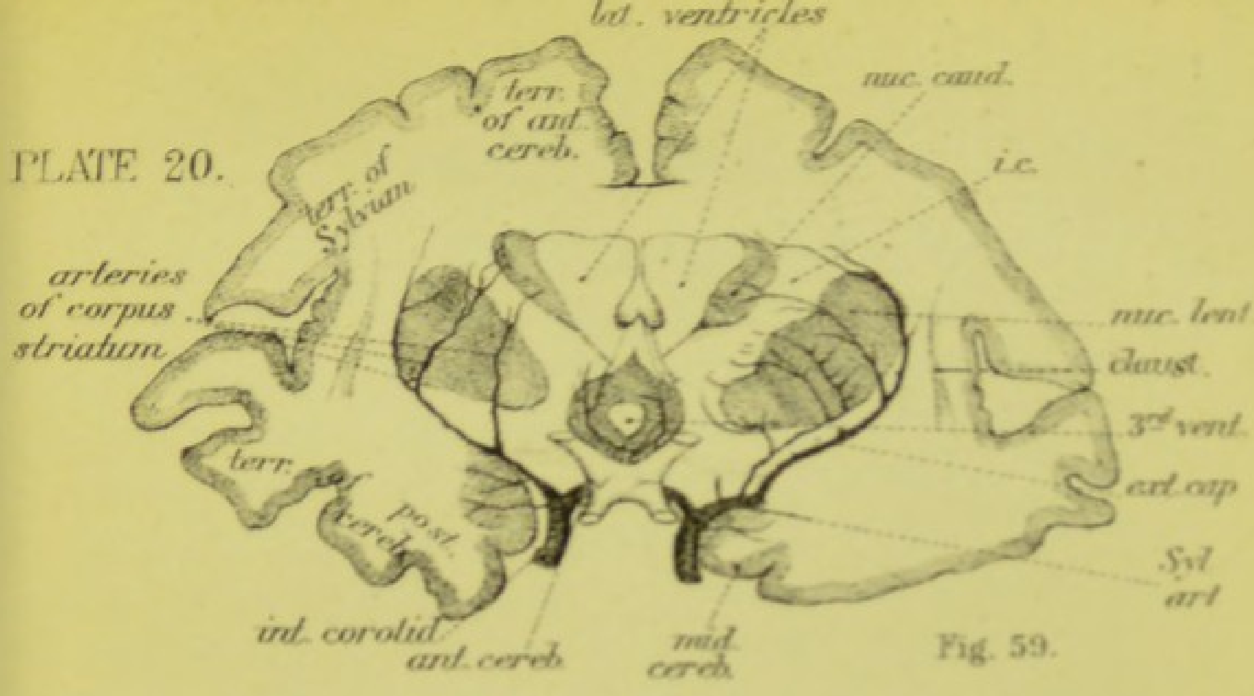


Fig. 59.

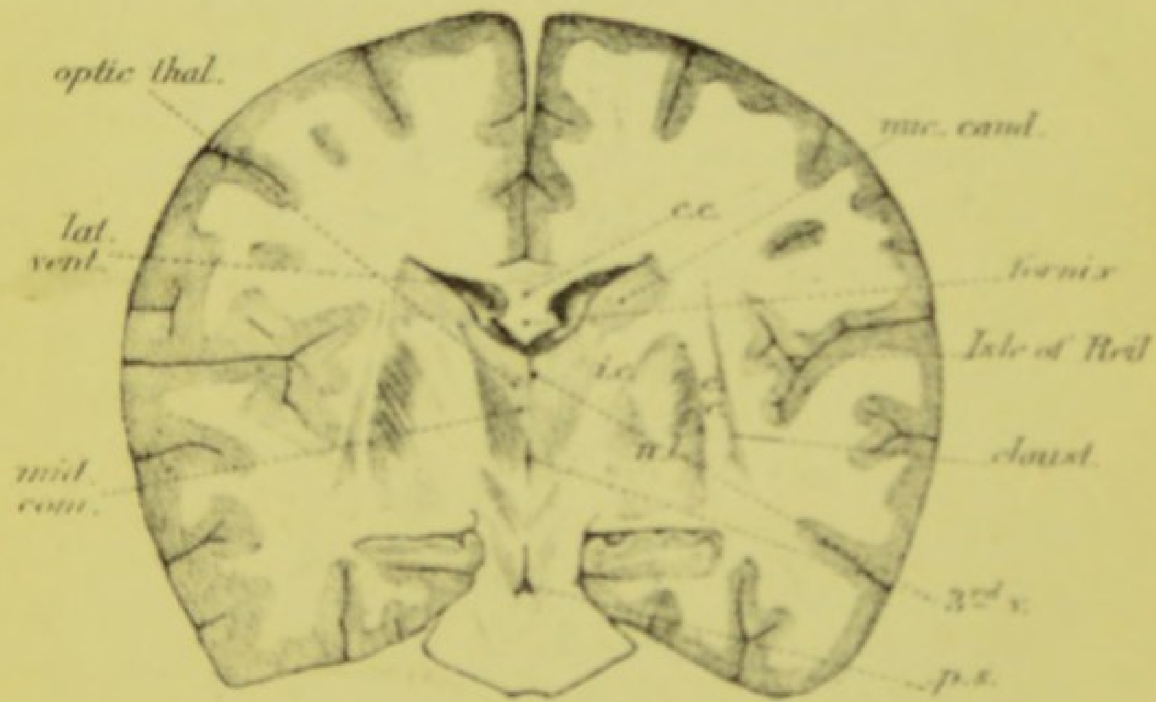


Fig. 60.

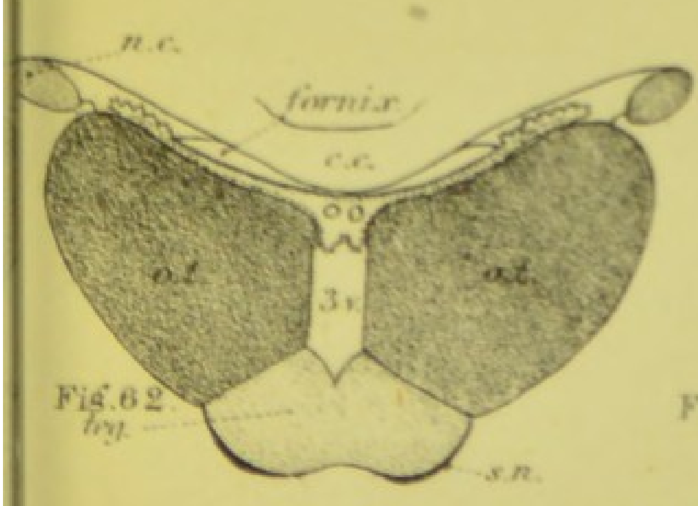


Fig. 62

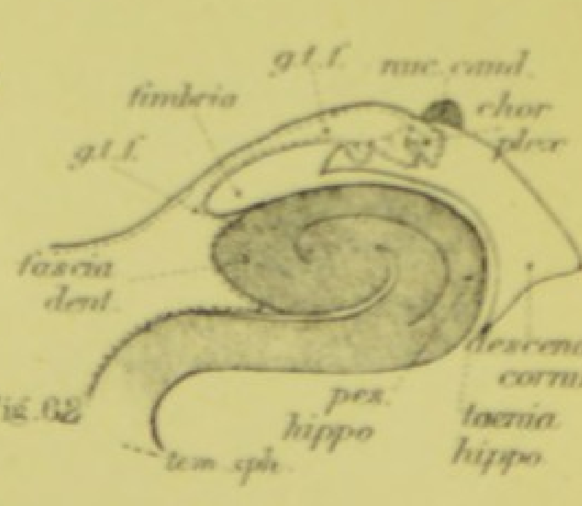


Fig. 62

part of the floor of the lateral ventricle and the wall of the 3rd ventricle, each optic thalamus consists of a central grey core, covered on the surface by a stratum of white matter, and, where they enter into the ventricular cavities, by ependyma and epithelium. Their anterior end is rounded—ANTERIOR TUBERCLE, and their posterior and external extremity swells out into a prominence—the POSTERIOR TUBERCLE or PULVINAR, which overhangs both the brachia of the corpora quadrigemina (fig. 24, c.g., page 24), and the two oval nodules (fig. 24, c.gen.)—the corpora geniculata interna and externa.

The *upper surface* of the thalami optici appears in the floor of the lateral ventricles, and upon it are the velum interpositum, the choroid plexus, and the edge of the fornix. The *under surface* rests behind on the crus cerebri (tegementum) and forms part of the roof of the descending horn. In front it lies over the corpus albicans and tuber cinereum.

Their *inner* (*mesial*) *surface* enters into the 3rd ventricle, and along each runs the peduncle of the pineal gland, while passing between them is the grey commissure. *Externally* the optic thalami blend with the substance of the hemispheres, their outer limit being the inner capsule.

In *front* of the optic thalami are the anterior pillars of the fornix (fig. 58, page 98, and fig. 53, page 84), passing to the base of the brain; and between the optic thalami and the pillars of the fornix is the foramen of Monro (fig. 53, page 84).

Behind the thalami are the posterior pillars of the fornix, winding down the descending horn of the lateral ventricle (fig. 55, page 92).

STRUCTURE.—The optic thalami are chiefly composed of grey matter arranged as three nuclei—anterior, outer, and inner. The course and relations of its white tracts are not yet understood.

"The Function of Basal Ganglia are as yet undecided. Anatomical appearances seem to be in harmony with the view that these ganglia are terminal stations of certain tracts of the cerebral peduncles, co-ordinate with, but not subordinate to, the grey matter of the cortex"—(Ferrier).

Corpora geniculata.—Below and external to the Pulvinar, are, as we have said, two pairs of oval eminences—the CORPORA GENICULATA INTERNA AND EXTERNA—the internal being below and mesial to the external, and separated from them by a band of white fibres, one of the roots of the optic tract (fig. 24, page 24, and fig. 51, page 84).

They consist of grey matter internally, and from each proceeds a white band to join the optic tracts. Similar tracts connect the external bodies to the nates and the internal to the testes.

The **Corpora Quadrigemina** (fig. 24, page 24, and fig. 51, page 84) are four rounded tubercules separated from each other by two grooves, the one longitudinal, the other transverse. They are placed in pairs, on each side of the middle line, behind the pineal gland and above the aqueduct of Sylvius; the anterior pair are called the nates, the posterior pair, the testes, and they rest upon a thin lamina—the lamina quadrigemina. Laterally each pair is prolonged into two white bands or cords—the ANTERIOR and POSTERIOR BRACHIA (fig. 24, page 24, and fig. 51, page 84)—the anterior passing between the corpora geniculata interna and externa, and thence to the optic tracts of which they are the direct roots; the posterior brachia runs forwards and outwards, and are lost beneath the corpora geniculata interna (figs. 24 and 51).

STRUCTURE.—The anterior pair of corpora quadrigemina consist of several layers of grey and white matter; the posterior pair of a central grey core and of a white cortex. Homologues of the corpora quadrigemina exist in all vertebrata. They invariably give origin to the optic nerves, and in size bear a direct relation to the animals power of sight.

In birds there are only two corpora, but they are very large, especially in those birds which have great powers of sight. In the mole the posterior pair are well developed, the anterior pair are rudimentary.

Injury to the optic nerves causes the anterior pair to waste, but leaves the posterior pair unaltered.

Pineal Gland (or Body) is a reddish, vascular, oval body, situated in the middle line above the aqueduct of Sylvius and in front of the corpora quadrigemina. Firmly attached to the velum interpositum, which gives it a special covering (fig. 57, page 96), it is connected to the cerebrum by two white bands—the PEDUNCLES—which, we have already seen, run one along the inner surface of each optic thalamus. The peduncles end in front by joining the anterior pillars of the Fornix. · Posteriorly the Pineal Gland is connected with the posterior commissure.

In STRUCTURE the gland is composed of follicles, separated by connective tissue, and filled with cells, calcareous particles (brain sand), and corpora amylacea.

III. THE COMMISSURES.

The Commissures of the Brain are longitudinal and traverse, and are the Corpus Callosum, the Fornix, the Anterior, Middle, and Posterior Commissures.

THE CORPUS CALLOSUM.—As you already know, the Corpus Callosum is the white transverse band of nerve fibres, which arches from before backwards in the middle line between the cerebral hemispheres and connects them together. About 4 inches long, it forms the floor of the great longitudinal fissure and the roof of the lateral ventricles, and reaches further forwards than backwards. It is thicker at the ends than in the middle of its extent, and is thickest and widest behind.

Anteriorly it turns downwards and backwards upon itself in the great longitudinal fissure, making a knee-shaped bend—the GENU (fig. 55, page 92, and fig. 53, page 84). Becoming gradually smaller it then forms a narrow median band—the ROSTRUM (fig. 53, page 84)—which ends below at the base of the brain by bifurcating into two tapering processes—the PEDUNCLES (fig. 24, page 24)—which, you will remember, have already been traced to the anterior perforated spot at the root of the fissure of Sylvius, and are there lost.

Posteriorly, on the other hand, the corpus callosum ends in a thickened free-rounded border or base—the SPLENIUM (fig. 53, page 84)—from the outer ends of which diverge two horn-shaped bundles of fibres into the occipital lobes.

The *upper surface* of the corpus callosum is marked along the middle line by a longitudinal groove—the RAPHÉ—on each side of and parellel to which you will see two or more faint lines—the MEDIAN LONGITUDINAL STRIÆ (nerves of Lancisi). Externally, under cover of the overhanging edge of the gyrus fornicatus, are similar longitudinal striæ—LATERAL LONGITUDINAL STRIÆ (tæniæ tectæ, covered band). The median striæ, when traced forwards, are joined in front by a prolongation of the lateral striæ, and pass with them round the anterior end of the corpus collosum to the anterior perforated spot; behind, the striæ diverge into the occipital lobes.

The *under surface* of the corpus callosum rests, in the posterior half of its extent, upon the body of the fornix, to which it is closely adherent, especially near the Splenium. In its anterior half, it is connected below with the vertical mesial partition—the *septum lucidum*—filling up, as we have seen, the space left between the fornix and concavity of the knee-shaped bend of the corpus callosum (fig. 53, page 84).

Laterally, the transverse fibres of the corpus callosum form the roof of the lateral ventricles, and diverge into the white substance of the hemispheres.

STRUCTURE.—The corpus collosum consists ot white nerve fibres which are in the main transverse, a few only being longitudinal. As they pass into the hemispheres they diverge in all directions, and probably go along with the fibres of the *corona radiata* to the grey matter of the cortex.

It is worthy of note that the corpus callosum may be absent without any ill effect.—(Holden).

The **FORNIX** (figs. 56 and 57, pages 94 and 96).—Beneath the corpus callosum, and more or less blended with it, especially behind, is a longitudinal system of commissural fibres—the FORNIX. It is an arched white band which connects the hippocampi with each other, and with the optic thalami. The fibres of which it is composed spring as two riband-like bands—the POSTERIOR PILLARS of the FORNIX or FIMBRIA—one on each side from the free surface of the hippocampus major (fig. 55, page 92, fig. 56, page 94, fig. 57, page 96), in the descending horn of the lateral ventricles. Ascending from the concave edge of the hippocampus the two pillars pass round the posterior end of the optic thalamus, and converging towards each other meet in the middle line to form a wide, flattened, triangular-shaped band—the BODY of the fornix—which has its apex directed forwards and its base backwards towards the splenium.

Superiorly the body of the fornix is in contact with the under surface of the corpus callosum; *inferiorly* it lies on the delicate lamina—the velum interpositum. *In front* its fibres diverge and pass downwards and forwards from the apex of the body, as two cylindrical processes, lying side by side—the ANTERIOR PILLARS—which can be traced downwards, in front of the optic thalami but behind the anterior commissure, to the base of the brain where they form the cortex of the *corpora albicantia*. Twisting on themselves like a figure of 8, they then reascend to the anterior tubercles of the optic thalami (fig. 53, page 84).

At the sides the fornix appears as a thin, free, sickle-shaped edge which rests upon the velum interpositum and the optic thalamus, and enters into the formation of the floor of the lateral ventricles. Originally the fornix consisted of two separate divisions, right and left, but these ultimately fuse in the middle line to form the body, their ends remaining free as the anterior and the posterior pillars of the fornix.

The **Tænia Semicircularis** is the narrow white band which lies in the groove between the nucleus caudatus and the optic thalamus. In front it joins the corresponding pillar of the fornix; behind it passes into the substance of the roof of the descending horn of the lateral ventricle.

The **Anterior, Middle,** and **Posterior Commissures** are connected with the 3rd ventricle (figs. 53 and 58, pages 84 and 98).

The **Anterior Commissure** is a round white cord which passes transversely across the middle line in front of the anterior pillars of the fornix. It connects together the corpora striata, and its fibres can be traced through those bodies, and below the nucleus lenticularis to the temporo-sphenoidal lobe.

The **Middle (Grey) Commissure** crosses the 3rd ventricle between the optic thalami. It is a strand of grey matter connected with the grey matter of the Thalami optici.

The **Posterior Commissure,** situated in front of, and below the pineal gland, but above the commencement of the passage into the 4th ventricle, is a rounded band which stretches between the optic thalami. Its fibres are said to come from the fillet (derived from the tegmentum of the crura cerebri), and to pass through the thalami to the hemispheres.

THE CRURA CEREBRI, OR CEREBRAL PEDUNCLES.

The **Cerebral Peduncles** (fig. 32, page 44, and fig. 48, page 78) are the two rounded masses which spring, in front, from the upper margin of the pons, and, diverging from each other, soon enter the base of the cerebral hemispheres.

It front, between the peduncles, lies the anterior perforated spot and the corpora albicantia; winding round their outer side are the optic tract; on their inner side is a groove, the oculomotor groove, from which the 3rd nerve takes its superficial origin; and on the dorsal aspect are the corpora quadrigemina, with the lamina quadrigemina, beneath which passes the aqueduct of Sylvius.

STRUCTURE.—A section at right angles to the crura will show you that they each consist of two portions, a posterior or dorsal, called the TEGMENTUM, and an anterior or ventral, called the PES or BASIS. These two parts of the crura are separated from each other by a narrow stratum of grey matter, called, from its dark colour, the LOCUS NIGER, the position of which is indicated on the surface by the oculomotor groove internally, and by another slight groove, the lateral sulcus, externally.

1. The **Tegmentum** (figs. 41 and 42, page 60) is the larger division of the crus, and, like the formatio reticularis of the Medulla and Pons, consists of a reticulum of longitudinal and transverse fibres interspersed with grey matter.

The longitudinal fibres come from the anterior and lateral columns of the spinal cord, and form the superior cerebellar peduncles. The best marked tracts are the posterior longitudinal bundle and the tract of the fillet; the former appearing in sections of the crura as two well marked strands on each side of the aqueduct of Sylvius; the latter, the fillet, appears on the surface of the crura as a tract of oblique white fibres (fig. 51, page 84).

The transverse fibres are as yet little understood.

The grey matter of the tegmentum consists of scattered cells, and of a definite collection lying beneath the anterior part of corpora quadrigemina, and known as the red nucleus or nucleus tegmenti (fig. 63, page 114), consisting of multipolar nerve cells. This nucleus is probably the primary termination of the superior cerebellar peduncles.

2. The **Pes, (Basis or Crusta)**—the ventral part of the peduncles—lies below the locus niger, and is chiefly composed of the pyramidal tracts of the medulla, though others are superadded, for transverse sections of the pes, as compared with the pyramids, show that other tracts have been added.

3. The **Substantia nigra** is a semilunar band of grey matter placed between the two divisions of the crus. It is characterised by darkly pigmented cells,

hence the name, and through it pass the roots of the 3rd nerve before they emerge at the oculomotor groove.

The two pedes are quite distinct from each other, whereas the two tegmenta are separated from each other merely by the median raphé.

INTERNAL AND EXTERNAL CAPSULES.

In treating of the Basal Ganglia (page 101) you will remember, we referred to two strands of white fibres, the INNER and OUTER CAPSULES, the former lying internal to, the later external to, the nucleus lenticularis. These so-called capsules are of the greatest importance clinically, for through them pass the chief motor and sensory tracts.

The **Internal Capsules** (fig. 58, page 98, and figs. 59 and 60, page 102).—Seen in horizontal section each internal capsule appears as a semi-lunar shaped band of white matter with its convexity directed towards the middle line. It can be divided into two divisions—an *anterior* and a *posterior*. The ANTERIOR DIVISION (fig. 58, i.e.) lies between the nucleus caudatus and the nucleus lenticularis; the POSTERIOR DIVISION (fig. 58, i.c.) lies between the optic thalamus and the nucleus lenticularis, and forms with the anterior division a sharp angle, or knee-shaped bend—the GENU (fig. 58 and 59). Thus the inner capsule may be said to consist of three parts—(1) A knee-shaped bend, the genu; (2) a part in front of the knee; (3) a part behind the knee (fig. 58). This capsule contains all the fibres of the foot of the crus cerebri of the same side except those that go to the nucleus lenticularis. Emerging from between the nucleus lenticularis and the tail of the caudate nucleus, and reinforced by fibres from the optic thalamus and the region below it, the fibres of the pes form a radiating, hollow fan-shaped mass of nerve fibres—the CORONA RADIATA—which spreads out into the cerebral cortex.

The tracts forming the knee, and the anterior ⅔ of the posterior division of the inner capsule are motor in function, and are in relation respectively, from before backwards, with the centres for the oro-lingual, facial, brachial, crural, and trunk muscles (Ferrier). Injury to this portion of the inner capsule results in loss of motion on the opposite side of the body.

The posterior ⅓, or more of the hinder division of the inner capsule, probably contains the sensory strands, for, when injured or diseased, there ensues loss of sensation, general and special, on the opposite side of the body, the motor powers not being affected, unless the leison implicates the motor tracts also (Ferrier).

The tracts and functions of the anterior division of the inner capsule, that in front of the genu, and the tracts and functions of the external capsule are as yet undecided.

Fig. 59 page 102 will give you an idea of the relations of the Sylvian artery, and the distribution of its branches to the capsules, and to the contiguous nuclei.

COURSE OF THE STRANDS OF NERVE FIBRES.

(Fig. 33, p. 48, and fig. 63, p. 114.)

Of the various strands of fibres described in the spinal cord, the course of the PYRAMIDAL TRACTS (crossed and direct) is alone known with any degree of certainty. Those tracts (crossed pyramidal, and direct pyramidal), after passing through the Medulla Oblongata, form the central portion of the foot of the corresponding crus cerebri,* and then ascend through the anterior part of the posterior division of the inner capsule, into the corona radiata, and finally, to the motor centres of the cerebral cortex (see fig. 63, c.p.t. and d.p.t.).

The DIRECT LATERAL CEREBELLAR TRACT of the spinal cord passes upwards to form part of the Restiform body; and, judging from the degeneration which follows its section, is probably connected with the SUPERIOR VERMIFORM PROCESS of its own side (Ferrier) (fig. 33, page 48, and fig. 63, page 114, d.l.c.).

The greater part of the fibres of the anterior and lateral columns of the cord enter the formatio reticularis of the Medulla and Pons (fig. 63, f.r.), some of the fibres there forming distinct strands, viz., the posterior longitudinal bundle and the fillet, which probably end in the region of the corpora quadrigemina and optic thalami.

Of the connections of the FUNICULUS GRACILIS and

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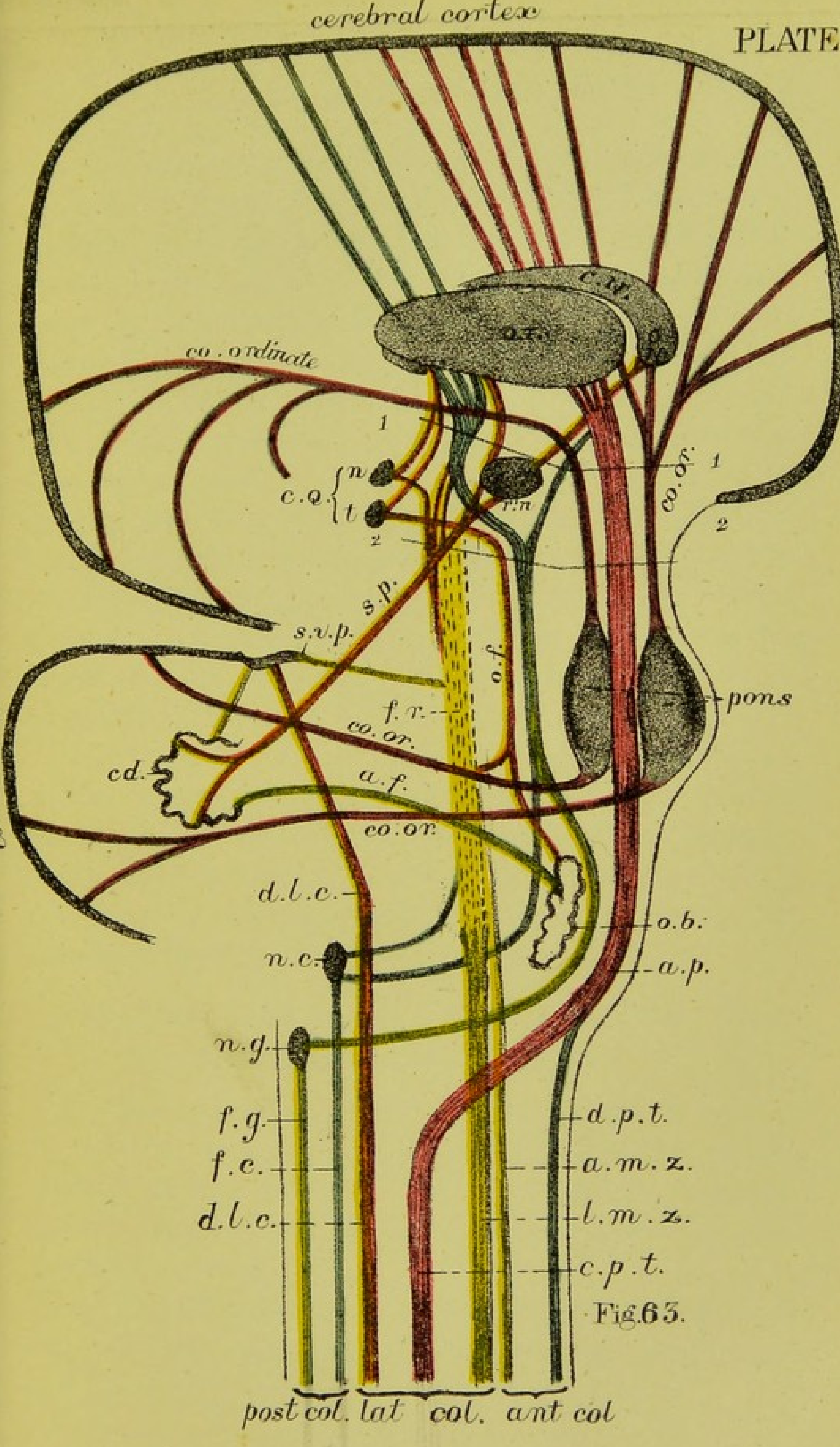
* Lines 1–1 and 2–2 in fig. 63 indicate the position of the pes and tegmentum of the crura cerebri.

cerebral cortex


cerebral cortex
C.N.
O.T.
co.ordinate
1
c.Q. {n
t
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r.n
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o.f.
f.r.
co.or.
pons
cerebellum
cd.
a.f.
co.or.
d.l.c.
o.b.
n.c.
a.p.
n.g.
f.g.
d.p.t.
f.c.
a.m.z.
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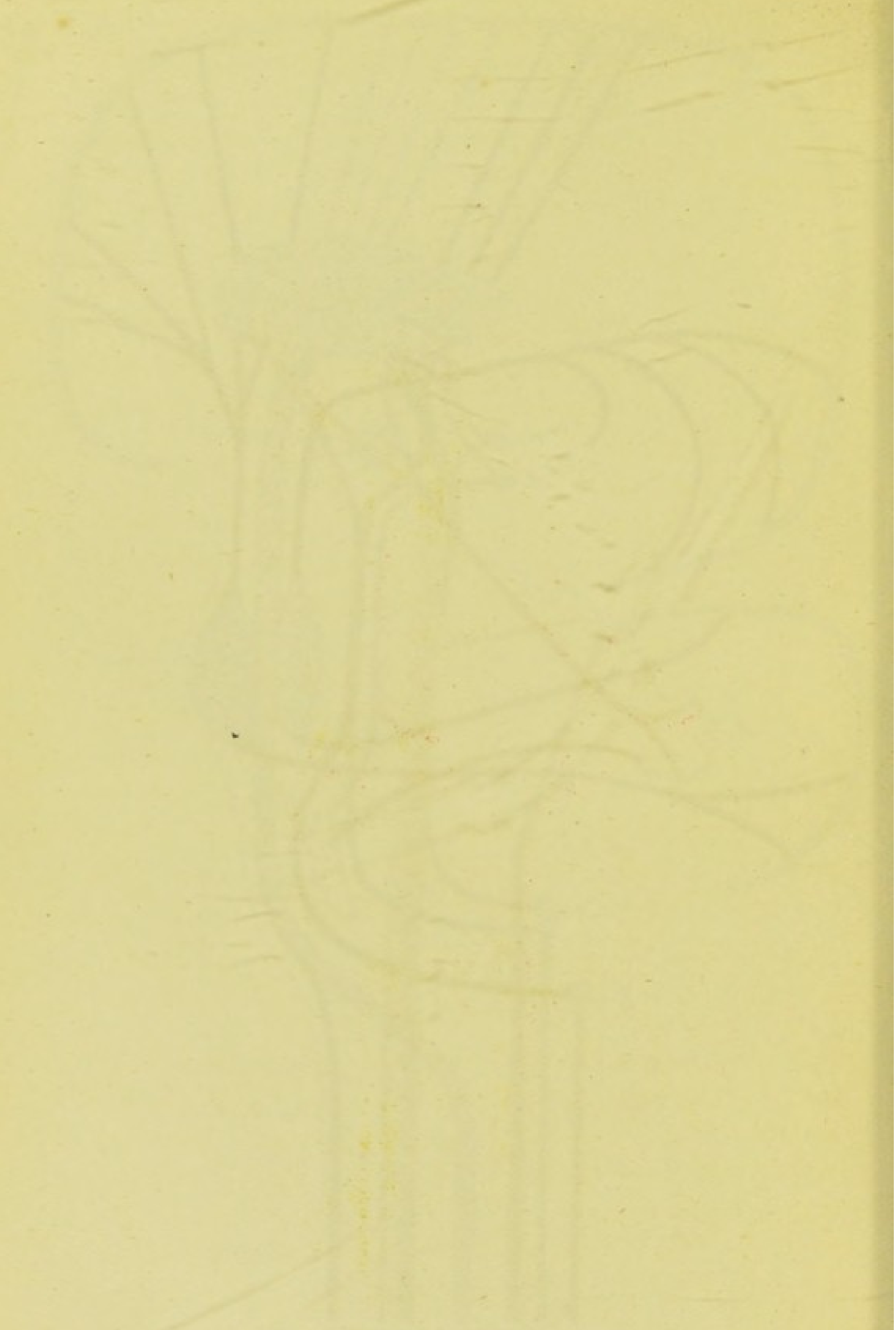
c.p.t.
post col. lat col. ant col

Fig.63.



the FUNICULUS CUNEATUS and their nuclei, nothing is definitely known (fig. 63, f.g. and f.c.). They ascend probably through the formatio reticularis (tract of the fillet) to the region of corpora quadrigemina, though some are said to go to the nucleus lenticularis, and to the posterior part of the inner capsule.

The ARCIFORM FIBRES probably connect the opposite olives with the dentate nucleus of the cerebellum (fig. 63, page 114 a.f.).

The SUPERIOR CEREBELLAR PEDUNCLES pass upwards beneath the corpora quadrigemina to the red nucleus of the tegmentum (fig. 63, r.n.), which is their primary termination, though it may be that some of the fibres pass on to the lenticular nucleus, and through the optic thalamus to the corona radiata (fig. 63, s.p.).

The transverse fibres of Pons—MIDDLE PEDUNCLE of the CEREBELLUM—are partly commissural between the cerebellar hemisphere, but many of them, through the multipolar nerve cells of the Pons (Nucleus Pontis), connect the cerebellar peduncles with the pyramidal stands of the opposite side (Ferrier).

SUPERFICIAL AND DEEP ORIGINS OF THE CRANIAL NERVES.

By the *superficial origins* of the cranial nerves is meant the points at which they are attached to the surface of the brain. Their *deep origins* are the several deep-seated nuclei to which they can ultimately be traced.

1. The **Olfactory Nerves,** 1st pair, spring from the olfactory bulbs and pass through the holes in the

cribriform plate of the ethmoid to be distributed to the upper part of the olfactory mucous membrane. The roots of the olfactory peduncles have already been noticed (page 78). We may add that the outer root can be traced to the extremity of the temporo-sphenoidal lobe, where it blends with the anterior end of the gyrus hippocampi. (Ferrier.).

2. The **Optic Nerves,** 2nd pair, are given off from the sides of the optic commissure, and enter the eye-ball through the optic foramen. Traced backwards they pass through the optic commissure round the outer sides of the crura cerebri, as the optic tracts, to the PULVINAR (posterior part of the optic thalamus), to the CORPORA GENICULATA, and, through their brachia, to the ANTERIOR pair of the CORPORA QUADRIGEMINA. In the optic tracts most of the fibres cross to the opposite eye, a few go to the optic nerve of the same side.

"The roots of the optic tracts which spring from the corpora geniculata interna have no real connection with vision, as they do not undergo atrophy like the other roots when the eyes are destroyed." (Ferrier.).

The **3rd Nerves** appear at the OCULOMOTOR GROOVE, on the inner side of the crura cerebri close to the Pons Varolii (fig. 48, page 78, and fig. 34, page 24). Traced backwards, they are found to pass through the tegmentum to a column of cells, on each side of the middle line, in the grey matter of the FLOOR of the AQUEDUCT OF SYLVIUS (fig. 42, page 60).

The **4th Nerves** will be seen on the outside of the crura cerebri, between the cerebrum and cerebellum (fig. 48, page 78). They are small and slender, and after decussating in the superior medullary velum, run in the wall of the aqueduct of Sylvius to a nucleus below that of the 3d nerve.

The **5th Nerves** spring from the sides of the pons near its upper margin, by two roots—a large one, *ganglionc*, and a small one, *aganglionic*.

The smaller—MOTOR ROOT—is the higher of the two, and is separated from the larger root by some of the transverse fibres of the Pons.

Followed backwards, the smaller part is seen to arise from the motor nucleus lying just below the LATERAL ANGLE of the 4TH VENTRICLE (fig. 34, page 54). It is joined by the descending root of the 5th nerve, which comes from the grey matter at the sides of the aqueduct of Sylvius.

The larger portion—the SENSORY ROOT—close to, but on the outside of the motor root (fig. 34), receives the ascending root, which springs from the nerve cells of the formatio reticularis of the Pons and Medulla.

The **6th Nerves** take their superficial origin near the middle line from the groove between the anterior pyramids of the medulla and the lower border of the Pons (fig. 48, page 78). Their deep origin is situated underneath the FASCICULUS TERES in the fore part of the floor of the 4th ventricle, just in front of the striæ acusticæ (fig. 34, page 54).

The **7th Nerve** consists of two parts—(1) the FACIAL PART (portio dura); (2) the AUDITORY PART (portio mollis). The FACIAL PART (7th) springs from the groove between the Pons and the restiform body, and behind the olive (fig. 48, page 78). Its deep origin is the facial nucleus is the formatio reticularis of the dorsal aspect of the Pons, near 6th and above the 5th nerve (fig. 34, page 54, and fig. 40, page 60).

The AUDITORY PORTION (8th nerve) arises from the same groove, but behind the facial and separated from it by the *pars intermedia*—a small bundle of nerve fibres between the facial and auditory, and connected with both. The deep origin of the *vestibular* division is in the VERMIS CEREBELLI or in GREY MATTER of the 4th VENTRICLE, beneath the superior cerebellar peduncle; the deep origins of the *cochlear* division is from the TUBERCULUM ACUSTICUM (Ferrier) (fig. 34, page 54).

N.B.—"The striæ acusticæ which look like the direct continuation of the posterior roots of the auditory nerve have no such relation."—Ferrier.

The **8th Nerves** consist of three parts (*a*) GLOSSO-PHARYNGEAL (9th nerve); (*b*) VAGUS (10th nerve); (*c*) SPINAL ACCESSORY (11th nerve). They take their superficial origin almost in a line with, but a little behind and below the 7th nerve (fig. 34, page 54). The spinal accessory has two portions—a spinal part which arises from the side of the spinal cord, as low as the 6th cervical nerve; and an accessory part which takes origin from the side of the medulla below the vagus. The GLOSSOPHARYNGEAL (fig. 34, 9), the VAGUS (fig. 34, 10), and the SPINAL ACCESSORY take their deep origins from a series of nuclei in a line with, but below that of the 7th nerve, and in the order from above downwards in which they are here enumerated. These nuclei lies beneath the ALA

CINEREA and INFERIOR FOVEA (fig. 33, page 48, and fig. 34, page 54).

The **9th Nerve** (12th) HYPOGLOSSAL, springs by several filaments from the groove between the anterior pyramids and the olives. Its deep origin is a column of cells close to the surface and near the middle line of the floor of the 4th ventricle, beneath the FASCICULUS TERES.

CHAPTER III.

Outline of the Development of the Brain and Spinal Cord.

One of the earliest steps in the development of the human embyro is the formation of what is known as the BLASTODERM or GERMINAL MEMBRANE. This membrane is composed of three distinct superimposed layers of cells, the EPIBLAST, the MESOBLAST, and the HYPOBLAST. The first of these, the EPIBLAST, is the one from which is developed, the central nervous system, the brain and spinal cord, as well as, in all probability, part of the peripheral nervous system.

On the dorsal aspect of the embryo, at a very early date, appear two ridges, separated from each other by an intervening furrow—the PRIMITIVE GROOVE. Gradually increasing in size, these two ridges grow upwards, and ultimately meet in the middle line on dorsal aspect, and, blending together, form a cylindrical longitudinal tube—PRIMITIVE MEDULLARY TUBE—with a wall of epiblastic cells. It is from this primitive tube that the Brain and Spinal Cord are developed; the walls giving rise to the *solid parts*, the cavity remaining as the various *ventricles*.

PLATE 22.

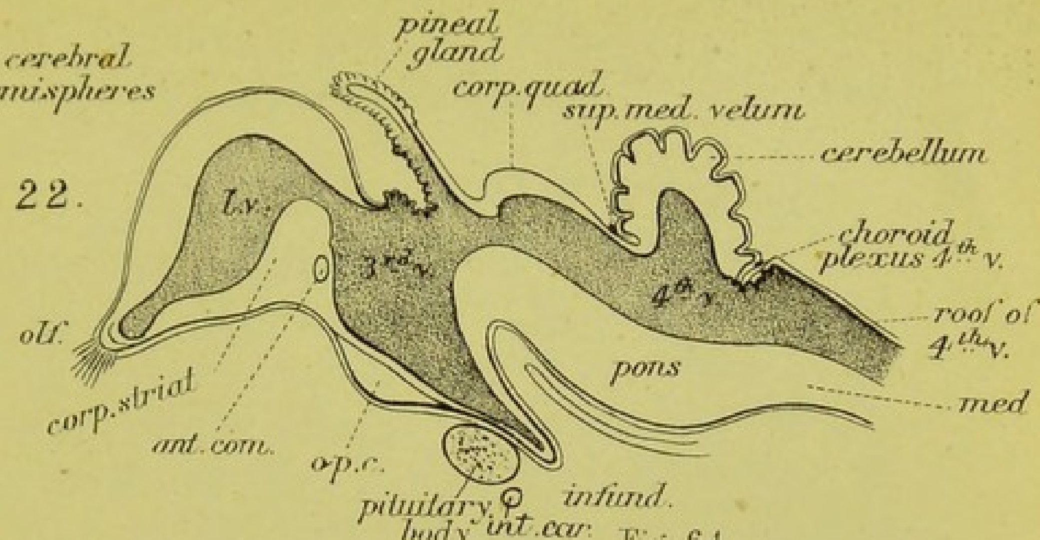


Fig. 64.

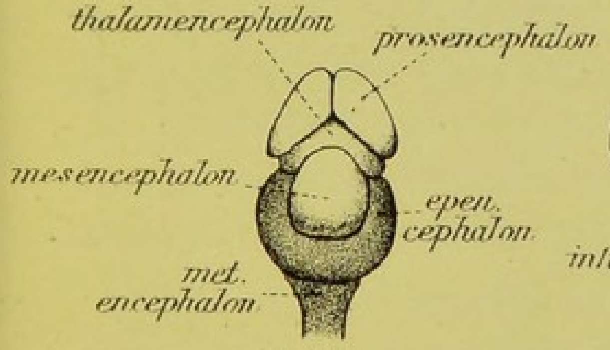


Fig. 65.

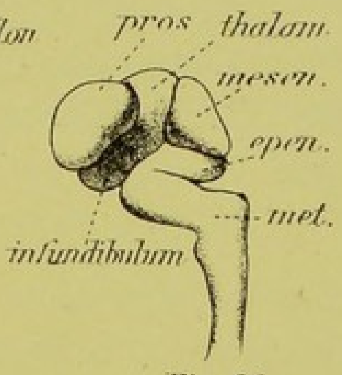


Fig. 66.

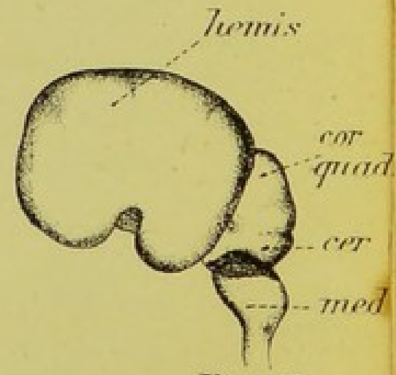


Fig. 67.

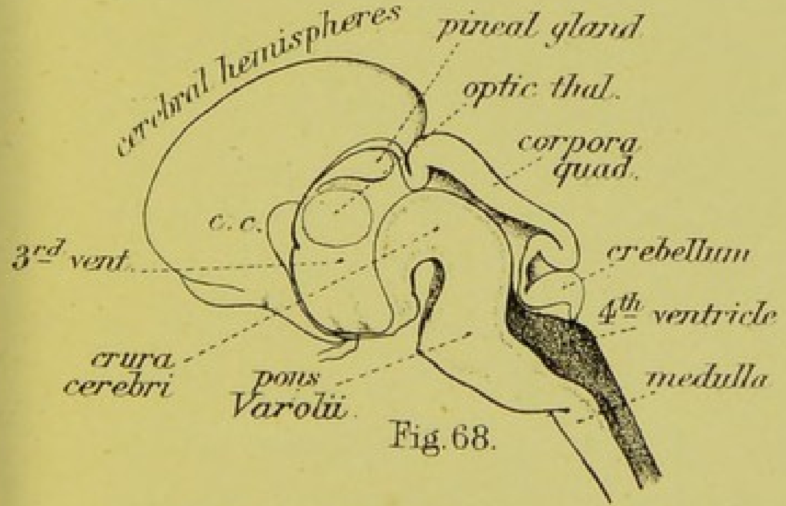


Fig. 68.

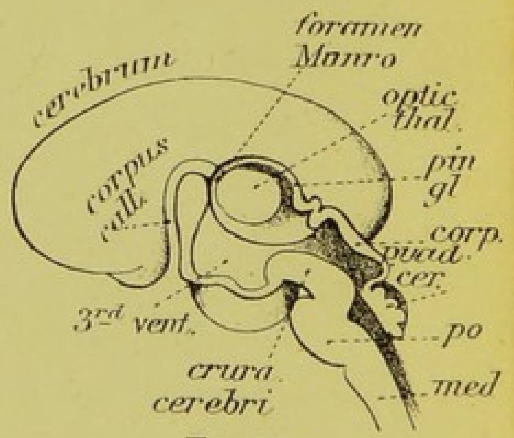


Fig. 69.

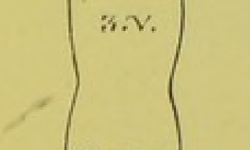


Fig. 70

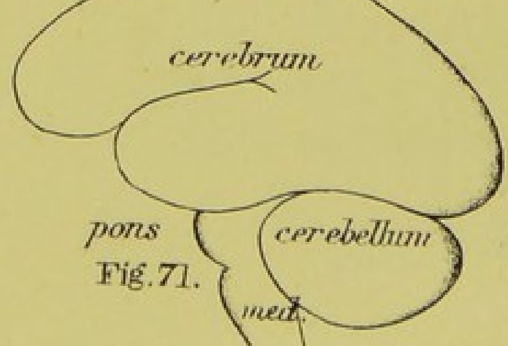


Fig. 71.

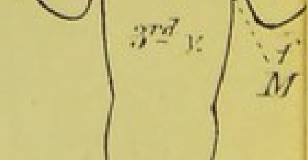


Fig. 72

I. The Spinal Cord.

The hinder part of the the primitve medullary tube gives rise to the spinal marrow. The lateral walls of this part of the tube increases much in thickness, so that the cavity of the tube is reduced to a mere slit. Soon the thickened walls meet in the middle line, in part of their extent, and subdivide the contained cavity into two divisions, an *upper* (posterior or dorsal), and an *inferior* (anterior or ventral). The *ventral division* becomes the CENTRAL CANAL (or ventricle) of the spinal cord; the *dorsal* division is partially obliterated, but what remains of it forms the POSTERIOR MEDIAN FISSURE of the spinal cord.

The layers of epiblast cells which form the wall of the canal now differentiate into the several parts of the cord. Thus the *innermost* layer of cells—those next the lumen of the tube—elongate, become ciliated, and form the lining cells of the central canal. The other layers of epiblast develope into the GREY CRESCENTS, and into the various WHITE STRANDS of the cord. As we have already seen in the account of the spinal cord, these white strands acquire their medullary sheaths at different dates, thus enabling us to map out the course they take through the spinal marrow (page 20).

The numbers 1, 2, 3, &c., in fig. 9, page 22, indicate the order in which these several strands are developed.

It is noteworthy that, at first, the spinal cord fills the entire length of the spinal canal, so that there is no cauda equina; but that by the rapid growth of the canal, as compared with the contained spinal marrow, the cord, at about the 9th month, reaches only as low as the 3rd lumbar vertebra.

II. THE BRAIN.

The Brain is formed from the forepart of the primitive medullary tube. This tube dilates considerably, but at first remains single. Its walls thicken, and after a time, the contained cavity becomes subdivided by two constrictions into the three segments, known as the ANTERIOR, the MIDDLE, and the POSTERIOR CEREBRAL VESICLES (figs. 64 and 70, plate 22, page 120). It is by the subsequent changes in these vesicles that the Brain with its subdivision and ventricles is formed.

(*a*) The **Posterior Cerebral Vesicle.**—This vesicle gives rise to the Medulla, the Pons, and the Cerebellum. Bending forwards at the upper end of the primitive spinal cord, the posterior vesicle makes a second knee-shaped bend backwards upon itself (fig. 66, page 120). The *forward bend* becomes developed into the 4TH VENTRICLE, and the contained cavity becomes the cavity of that ventricle. The *knee* of the bend gives rise to the PONS, while the *backward fold* becomes the CEREBELLUM of which the central lobe is first formed, the lateral lobes being a subsequent development.

ii. The **Middle Cerebral Vesicle** likewise bends forwards from the posterior vesicle, but remains single. In its *roof* are formed the CORPORA QUADRIGEMINA, in its *floor*, the CRURA CEREBRI, while the original CENTRAL CANAL, much narrowed by the growth of these parts, remains as the AQUEDUCT OF SYLVIUS—iter a tertio ad quartum ventriculum (figs. 67 aud 69, page 120).

iii. The **Anterior Cerebral Vesicle** may be subdivided into two portions, an anterior and a posterior. The entire vesicle bends forwards on the middle vesicle, which now forms the most prominent part of the head. From each side of its *posterior* segement is developed the OPTIC VESICLES, which ultimately become the optic nerves and the retina. In its *posterior* and *outer* wall are developed the two OPTIC THALAMI, separated from each other by a median cleft—the 3RD VENTRICLE—part of the original cavity. Anteriorly the floor of the ventricle is prolonged downwards as a funnel-shaped tube—the INFUNDIBULUM—connected with the PITUITARY BODY (fig. 66, page 120). Behind, on the other hand, the cavity communicates with the 4th ventricle through a narrow channel, the continuation backwards of the original cavity—AQUEDUCT OF SYLVIUS. The posterior part of the roof rapidly becomes thinner and is reduced to a mere lamina connected afterwards with the pia mater and choroid plexus of the 3rd ventricle.

The *fore* part of the anterior cerebral vesicle bulges forward as a median mass, at first single, but which soon becomes divided by a longitudinal cleft into two lateral segments.

These *lateral segments* become the CEREBRAL HEMISPHERES, and the *median cleft* forms the GREAT LONGITUDINAL FISSURE. The cavity within these lateral enlargements remains as LATERAL VENTRICLES, which are connected with each other by a constantly narrowing neck, the FORAMEN OF MONRO (see fig. 72, page 120). In the *floor* of the ventricles appears a grey mass—the CORPUS STRIATUM—streaked with white matter giving it the striated appearance from which it takes its name.

The *roof* and *walls* of the cavity form, at first, an evenly expanded mass of grey matter, which, however, soon becomes convoluted and furrowed, giving rise to the FISSURES, LOBES, and GYRI of the cerebral hemispheres. Increasing rapidly in size these hemispheres grow backwards, and, finally, completely overlap and hide the other subdivisions of the Brain. On the inner aspect of the cerebral walls a longitudnal white band grows inwards towards the middle line, and there meets its fellow of the opposite side to form the central part or BODY of the FORNIX, which is continuous in front with the ANTERIOR PILLARS, behind with the diverging POSTERIOR PILLARS. Above the fornix, separated from it by a groove, appears a transverse band of white nerve fibres, which joins a similar band on the opposite wall. They together form the CORPUS CALLOSUM, the great commissure uniting the cerebral hemispheres. This commissural band is in contact with the upper surface of the fornix posteriorly, but anteriorly it arches downwards in the median fissure, some distance in front of the fornix, thus leaving between them a triangular interval, bounded on each side by a layer of grey matter derived from the hemispheres. These lamina form, the SEPTUM LUCIDUM, the vertical partition separating the lateral ventricles. Between them, is enclosed the cavity of the 5th VENTRICLE, or ventricle of the septum, which you will readily understand, is not, like the rest of the ventricle, part of from the primitive medullary cavity, but is merely a portion of the great lngitudinal fissure which has become enclosed in the process of development.

TABLE OF THE CEREBRAL VESICLES AND THE PARTS DEVELOPED FROM EACH.

1. Anterior vesicle.	i. Prosencephalon Fore-brain.	Cerebral Hemispheres. Corpora Striata. Corpus Callosum. Fornix. Lateral Ventricles. Olfactory Lobe.
	ii. Thalamencephalon Inter-brain.	Optic Thalami. Pineal. Body. Pituitary Body. 3d Ventricle. Optic Nerve.
2. Middle vesicle.	iii. Mesencephalon Mid-brain.	Corpora Quadrigemina. Crura Cerebri. Aqueduct of Sylvius. Optic Nerve.
3. Posterior vesicle.	iv. Epencephalon Hindbrain.	Cerebellum. Pons Varolii. Anterior part of the 4th ventricle.
	v. Metencephalon After-brain.	Medulla Oblongata. Posterior part of 4th ventricle. Auditory Nerve.

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